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USACE / NAVFAC / AFCESA **UFGS-15951A (December 2001)**

Preparing Activity: USACE **Superseding UFGS-15951A (June 1998)**

UNIFIED FACILITIES GUIDE SPECIFICATIONS

Latest change indicated by CHG tags
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SECTION 15951A

DIRECT DIGITAL CONTROL FOR HVAC
12/01

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NOTE: This guide specification covers the requirements for direct digital control for HVAC.

Comments and suggestions on this guide specification are welcome and should be directed to the technical proponent of the specification. A listing of technical proponents**, including their organization designation and telephone number, is on the Internet.**

Use of electronic communication is encouraged.
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PART 1 GENERAL

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NOTE: This specification is for use in projects which require local control of HVAC equipment using DDC. It is primarily intended for facilities which will be operated in a stand-alone mode. For projects which involve: a) the installation of DDC in multiple facilities, or b) monitoring or control of processes other than HVAC, or c) monitoring/control of multiple facilities using dynamically updated real-time data, the designer should consider the use of CEGS-16935 UTILITY MONITORING AND CONTROL SYSTEM (UMCS).

The HVAC Controls System design shall be in accordance with TI 810-11. This specification is based on the use of standard HVAC control systems and the designer shall coordinate the design with this specification. Additionally, the standard drawings, as delineated in TI 810-11, must be utilized in the preparation of the contract drawings and those drawings must be included in the completed design package. Templates for typical contract type drawings, based on the standard drawings in TI 810-11, have been developed and are available in AutoCAD and MicroStation formats from U.S. Army Engineer District, Savannah, ATTN: CESAS-EN-DM,

P.O. Box 889, Savannah, GA 31402-0889, telephone 912-652-5386.

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1.1 REFERENCES

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NOTE: Issue (date) of references included in project specifications need not be more current than provided by the latest change (Notice) to this guide specification.

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The publications listed below form a part of this specification to the extent referenced. The publications are referred to in the text by basic designation only.

AIR MOVEMENT AND CONTROL ASSOCIATION (AMCA)

AMCA 500	(11989; Rev994) Test Methods for Louvers, Dampers and Shutters

AMERICAN NATIONAL STANDARDS INSTITUTE (ANSI)

ANSI C12.1	(1995) Code for Electricity Metering

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)

ASTM A 269	(1996) Seamless and Welded Austenitic Stainless Steel Tubing for General Service
ASTM B 88	(1996) Seamless Copper Water Tube
ASTM B 88M	(1996) Seamless Copper Water Tube (Metric)
ASTM D 1693	(1997a) Environmental Stress-Cracking of Ethylene Plastics
ASTM D 635	(1997) Rate of Burning and/or Extent and Time of Burning of Self-Supporting Plastics in a Horizontal Position

ASME INTERNATIONAL (ASME)

ASME B16.34	(199; B16.34a) Valves - Flanged, Threaded, and Welding End
ASME B40.1	(1991) Gauges - Pressure Indicating Dial Type - Elastic Element
ASME BPVC SEC VIII D1	(1998) Boiler and Pressure Vessel Code; Section VIII, Pressure Vessels Division 1 - Basic Coverage

ELECTRONIC INDUSTRIES ALLIANCE (EIA)

EIA ANSI/EIA/TIA-232-F	(1991) Interface Between Data Technical

	Equipment and Data Circuit-Terminating Equipment Employing Serial Binary Data Interchange

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

IEEE C62.41	(1991; R 1995) Surge Voltages in Low-Voltage AC Power Circuits
IEEE Std 142	(1991) IEEE Recommended Practice for Grounding of Industrial and Commercial Power Systems

INSTRUMENT SOCIETY OF AMERICA (ISA)

ISA S7.0.01	(1996) Quality Standard for Instrument Air

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA 250	(1991) Enclosures for Electrical Equipment (1000 Volts Maximum)
NEMA ICS 1	(1993) Industrial Control and Systems
NEMA ST 1	(1988) Specialty Transformers (Except General-Purpose Type)

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70	(1999) National Electrical Code
NFPA 90A	(1996) Installation of Air Conditioning and Ventilating Systems

UNDERWRITERS LABORATORIES (UL)

UL 268A	(1998) Smoke Detectors for Duct Application
UL 508	(1993; Rev thru Oct 1997) Industrial Control Equipment
UL 555S	(1996) Leakage Rated Dampers for Use in Smoke Control Systems
UL 94	(1996; Rev thru Jul 1998) Tests for Flammability of Plastic Materials for Parts in Devices and Appliances

1.2 GENERAL REQUIREMENTS

The direct digital control (DDC) shall be a complete system suitable for the heating, ventilating and air-conditioning (HVAC) system.

1.2.1 Nameplates, Lens Caps, and Tags

Nameplates and lens caps bearing legends as shown and tags bearing device-unique identifiers as shown shall have engraved or stamped characters. A plastic or metal tag shall be mechanically attached directly to each device or attached by a metal chain or wire. Each airflow measurement station shall have a tag showing flow rate range for signal output range, duct size, and identifier as shown.

1.2.2 Verification of Dimensions

After becoming familiar with all details of the work, the Contractor shall verify all dimensions in the field, and shall advise the Contracting Officer of any discrepancy before performing any work.

1.2.3 Drawings

Because of the small scale of the drawings, it is not possible to indicate all offsets, fittings, and accessories that may be required. The Contractor shall carefully investigate the mechanical, electrical, and finish conditions that could affect the work to be performed, shall arrange such work accordingly, and shall furnish all work necessary to meet such conditions.

1.2.4 Power-Line Surge Protection

Equipment connected to ac circuits shall be protected from power-line surges. Equipment protection shall meet the requirements of IEEE C62.41. Fuses shall not be used for surge protection.

1.2.5 Surge Protection for Transmitter and Control Wiring

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NOTE: Determine if any additional inputs or outputs require surge protection and show the requirement for them on the drawings.

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DDC system control-panel equipment shall be protected against surges induced on control and transmitter wiring installed outside and as shown. The equipment protection shall be tested in the normal mode and in the common mode, using the following two waveforms:

a. A 10-microsecond by 1,000-microsecond waveform with a peak voltage of 1,500 volts and a peak current of 60 amperes.

b. An eight microsecond by 20-microsecond waveform with a peak voltage of 1,000 volts and a peak current of 500 amperes.

1.2.6 System Overall Reliability Requirement

The system shall be configured and installed to yield a mean time between failure (MTBF) of at least 40,000 hours. Each DDC controller shall be designed, configured, installed and programmed to provide for stand alone operation with minimal performance degradation on failure of other system components to which it is connected or with which it communicates.

1.2.7 DDC System Network Accessibility

Where the systems to be controlled by the DDC system are located in multiple mechanical rooms, each mechanical room shall have at least one communication port for the portable workstation/tester. DDC controllers shall be located in the same room as the equipment being controlled or in an adjacent space which has direct access to the equipment room.

1.2.8 System Accuracy and Display

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NOTE: Show sensor ranges and ratings on drawings for measurements such as pressure and flow. Add requirements for additional site specific measurements, including span and accuracy for any special application not included in this specification.

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The system shall maintain an end-to-end accuracy for one year from sensor to operator's console display for the applications specified and shall display the value as specified. Each temperature shall be displayed and printed to nearest 0.1 degree F.

1.2.8.1 Space Temperature

Space temperature with a range of 50 to 85 degrees F plus or minus 0.75 degree F for conditioned space; 30 to 130 degrees F plus or minus 1 degree F for unconditioned space.

1.2.8.2 Duct Temperature

Duct temperature with a range of 40 to 140 degrees F plus or minus 2 degrees F.

1.2.8.3 Outside Air Temperature

Outside air (OA) temperature with a range of minus 30 to plus 130 degrees F plus or minus 2 degrees F; with a subrange of 30 to 100 degrees F plus or minus 1 degree F.

1.2.8.4 Water Temperature

Water temperature with a range of 30 to 100 degrees F plus or minus 0.75 degree F; the range of 100 to 250 degrees F plus or minus 2 degrees F; and water temperatures for the purpose of performing Btu calculations using differential temperatures to plus or minus 0.5 degree F using matched sensors.

1.2.8.5 High Temperature

High temperature with a range of 200 to 500 degrees F plus or minus 2.0 degrees F.

1.2.8.6 Relative Humidity

Relative humidity, within a range of 20 to 80 percent, plus or minus 6.0 percent of range (display and print to nearest 1.0 percent).

1.2.8.7 Pressure

Pressure with a range for the specific application plus or minus 2.0 percent of range (display and print to nearest psi.)

1.2.8.8 Flow

Flow with a range for the specific application plus or minus 3.0 percent of range, and flows for the purpose of thermal calculations to plus or minus 2.0 percent of actual flow (display and print to nearest unit, such as gallons per minute).

1.2.8.9 KWh and kW Demand

KWh and kW demand with a range for the specific application plus or minus 1.0 percent of reading (display and print to nearest kWh or kW).

1.2.8.10 Analog Value Input

An analog value input to the system's equipment via an AI with a maximum error of 0.50 percent of range, not including the sensor or transmitter error. This accuracy shall be maintained over the specified environmental conditions.

1.3 SUBMITTALS

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NOTE: Submittals must be limited to those necessary for adequate quality control. The importance of an item in the project should be one of the primary factors in determining if a submittal for the item should be required.

Indicate submittal classification in the blank space following the name of the item requiring the submittal by using "G" when the submittal requires Government approval. Submittals not classified as "G" will show on the submittal register as "Information Only". For submittals requiring Government approval, a code of up to three characters should be used following the "G" designation to indicate the approving authority; codes of "RE" for Resident Engineer approval, "ED" for Engineering approval, and "AE" for Architect-Engineer approval are recommended.

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Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government. The following shall be submitted in accordance with Section 01330 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

HVAC Control System; [_____], [_____]

Drawings shall be on 34 by 22 inch sheets in the form and arrangement shown. The drawings shall use the same abbreviations, symbols, nomenclature and identifiers shown. Each control system element on a drawing shall have a unique identifier as shown. The HVAC Control System Drawings shall be delivered together as a complete submittal. Deviations must be approved by the Contracting Officer. Drawings shall be submitted along with Submittal SD-01, Data.

a. HVAC Control System Drawings shall include the following:

Sheet One: Drawing Index, HVAC Control System Legend.

Sheet Two: Valve Schedule, Damper Schedule.

Sheet Three: Compressed Air Station Schematic.

Sheet Four: Control System Schematic and Equipment Schedule.

Sheet Five: Sequence of Operation and Data Terminal Strip Layout.

Sheet Six: Control Loop Wiring Diagrams.

Sheet Seven: Motor Starter and Relay Wiring Diagram.

Sheet Eight: Communication Network and Block Diagram.

Sheet Nine: DDC Panel Installation and Block Diagram.

(Repeat Sheets Four through Seven for each AHU System.)

b. The HVAC Control System Drawing Index shall show the name and number of the building, military site, State or other similar designation, and Country. The Drawing Index shall list HVAC Control System Drawings, including the drawing number, sheet number, drawing title, and computer filename when used. The HVAC Control System Legend shall show generic symbols and the name of devices shown on the HVAC Control System Drawings.

c. The valve schedule shall include each valve's unique identifier, size, flow coefficient Cv, pressure drop at specified flow rate, spring range, positive positioner range, actuator size, close-off pressure data, dimensions, and access and clearance requirements data. Valve schedules may be submitted in advance but shall be included in the complete submittal.

d. The damper schedule shall contain each damper's and each actuator's identifier, nominal and actual sizes, orientation of axis and frame, direction of blade rotation, spring ranges, operation rate, positive positioner ranges, locations of actuators and damper end switches, arrangement of sections in multi-section dampers, and methods of connecting dampers, actuators, and linkages. The Damper Schedule shall include the maximum leakage rate at the operating static-pressure differential. The Damper Schedule shall contain actuator selection data supported by calculations of the torque required to move and seal the dampers, access and clearance requirements. Damper schedules may be submitted in advance but shall be included in the complete submittal.

e. The compressed air station schematic diagram shall show all equipment, including: compressor with motor horsepower and voltage; starter; isolators; manual bypasses; tubing sizes; drain piping and drain traps; reducing valves; dryer; and data on manufacturer's names and model numbers, mounting, access, and clearance requirements. Air Compressor and air dryer data shall include calculations of the air consumption of all current-to-pneumatic transducers and of any other control system devices to be connected to the compressed air station, and the compressed air supply dewpoint temperature at 20 psig. Compressed air station schematic drawings shall be submitted for each compressed air station.

f. The HVAC control system schematics shall be in the form shown, and shall show all control and mechanical devices associated with the HVAC system. A system schematic drawing shall be submitted for each HVAC system.

g. The HVAC control system equipment Schedule shall be in the form shown. All devices shown on the drawings having unique identifiers shall be referenced in the equipment schedule. Information to be included in the equipment schedule shall be the control loop, device unique identifier, device function, setpoint, input range, and additional important parameters (i.e., output range). An equipment schedule shall be submitted for each HVAC system.

h. The HVAC control system sequence of operation shall reflect the language and format of this specification, and shall refer to the devices by their unique identifiers as shown. No operational deviations from specified sequences will be permitted without prior written approval of the Contracting Officer. Sequences of operation shall be submitted for each HVAC control system including each type of terminal unit control system.

i. The HVAC control system wiring diagrams shall be functional wiring diagrams which show the interconnection of conductors and cables to HVAC control panel terminal blocks and to the identified terminals of devices, starters and package equipment. The wiring diagrams shall show necessary jumpers and ground connections. The wiring diagrams shall show the labels of all conductors. Sources of power required for HVAC control systems and for packaged equipment control systems shall be identified back to the panel board circuit breaker number, HVAC system control panel, magnetic starter, or packaged equipment control circuit. Each power supply and transformer not integral to a controller, starter, or packaged equipment shall be shown. The connected volt-ampere load and the power supply volt-ampere rating shall be shown. Wiring diagrams shall be submitted for each HVAC control system.

SD-03 Product Data

Service Organizations; [_____], [_____]

[Six] [_____] copies of a list of service organizations qualified to service the HVAC control system. The list shall include the service organization name, address, technical point of contact and telephone number, and contractual point of contact and telephone number.

Equipment Compliance Booklet; [_____], [_____]

The HVAC Control System Equipment Compliance Booklet (ECB) shall be in booklet form and indexed, with numbered tabs separating the information on each device. It shall consist of, but not be limited to, data sheets and catalog cuts which document compliance of all devices and components with the specifications. The ECB shall be indexed in alphabetical order by the unique identifiers. Devices and components which do not have unique identifiers shall follow the devices and components with unique identifiers and shall be indexed in alphabetical order according to their functional name. The ECB shall include a Bill of Materials for each HVAC Control System. The Bill of Materials shall function as the Table of Contents for the ECB and shall include the device's unique identifier, device function, manufacturer, model/part/catalog number used for ordering, and tab number where the device information is located in the ECB. The ECB shall be submitted along with Submittal SD-04, Drawings.

Commissioning Procedures; [_____], [_____]

[Six] [_____] copies of the HVAC control system commissioning procedures, in booklet form and indexed, 60 days prior to the scheduled start of commissioning. Commissioning procedures shall be provided for each HVAC control system, and for each type of terminal unit control system. The Commissioning procedures shall reflect the format and language of this specification, and refer to devices by their unique identifiers as shown. The Commissioning procedures shall be specific for each HVAC system, and shall give detailed step-by-step procedures for commissioning of the system.

a. The Commissioning procedures shall include detailed, product specific set-up procedures, configuration procedures, adjustment procedures, and calibration procedures for each device. Where the detailed product specific commissioning procedures are included in manufacturer supplied manuals, reference may be made in the HVAC control system commissioning procedures to the manuals.

b. An HVAC control system commissioning procedures equipment list shall be included that lists the equipment to be used to accomplish commissioning. The list shall include manufacturer name, model number, equipment function, the date of the latest calibration, and the results of the latest calibration.

Performance Verification Test Procedures; [_____], [_____]

[Six] [_____] copies of the HVAC Control System Performance Verification Test Procedures, in booklet form and indexed, 60 days before the Contractor's scheduled test dates. The performance verification test procedures shall refer to the devices by their unique identifiers as shown, shall explain, step-by-step, the actions and expected results that will demonstrate that the HVAC control system performs in accordance with the sequences of operation, and other contract documents. An HVAC control system performance verification test equipment list shall be included that lists the equipment to be used during performance verification testing. The list shall include manufacturer name, model number, equipment function, the date of the latest calibration, and the results of the latest calibration.

Training; [_____], [_____]

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NOTE: Training requirements should be coordinated with the user. Extent of training should be based on the needs of the operation and maintenance staff.
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An outline for the HVAC control system training course with a proposed time schedule. Approval of the planned training schedule shall be obtained from the Government at least [60] [_____] days prior to the start of the training. [Six] [_____] copies of HVAC control system training course material 30 days prior to the scheduled start of the training course. The training course material shall include the operation manual, maintenance and repair manual, and paper copies of overheads used in the course.

SD-06 Test Reports

Commissioning Report; [_____], [_____]

[Six] [_____] copies of the HVAC Control System Commissioning Report, in booklet form and indexed, within 30 days after completion of the system commissioning. The commissioning report shall include data collected during the HVAC control system commissioning procedures and shall follow the format of the commissioning procedures. The commissioning report shall include all configuration checksheets with final values listed for all parameters, setpoints, P, I, D setting constants, calibration data for all devices, results of adjustments, and results of testing.

Performance Verification Test; [_____], [_____]

[Six] [_____] copies of the HVAC Control System Performance Verification Test Report, in booklet form and indexed, within 30 days after completion of the test. The HVAC control system performance verification test report shall include data collected during the HVAC control system performance verification test. The original copies of all data gathered during the performance verification test shall be turned over to the Government after Government approval of the test results.

SD-07 Certificates

Air Storage Tank; [_____], [_____]

An ASME Air Storage Tank Certificate for each storage tank.

SD-10 Operation and Maintenance Data

Operation Manual; [_____], [_____]
Maintenance and Repair Manual; [_____], [_____]

[Six] [_____] copies of the [HVAC Control System Operation Manual] [and] [HVAC Control System Maintenance and Repair Manual], for each HVAC control system, 30 days before the date scheduled for the training course.

1.4 DELIVERY AND STORAGE

Products shall be stored with protection from the weather, humidity and temperature variations, dirt and dust, and other contaminants, within the storage condition limits published by the equipment manufacturer. Dampers shall be stored so that seal integrity, blade alignment and frame alignment are maintained.

1.5 OPERATION MANUAL

An HVAC control system operation manual in indexed booklet form shall be provided for each HVAC control system. The operation manual shall include the HVAC control system sequence of operation, and procedures for the HVAC system start-up, operation and shut-down. The operation manual shall include as-built HVAC control system detail drawings. The operation manual shall include the as-built configuration checksheets, the procedures for changing HVAC control system setpoints, and the procedures for placing HVAC system controllers in the manual control mode.

a. The procedures for changing HVAC control system setpoints shall describe the step-by-step procedures required to change the process variable setpoints, the alarm setpoints, the bias settings, and setpoint reset schedules.

b. The procedures for placing HVAC system controllers in the manual control mode shall describe step-by-step procedures required to obtain manual control of each controlled device and to manually adjust their positions.

1.6 MAINTENANCE AND REPAIR MANUAL

An HVAC control system maintenance and repair manual in indexed booklet form in hardback binders shall be provided for each HVAC control system. The maintenance and repair manual shall include the routine maintenance checklist, a recommended repair methods list, a list of recommended maintenance and repair tools, the qualified service organization list, the as-built commissioning procedures and report, the as-built performance verification test procedures and report, and the as-built equipment data booklet.

a. The routine maintenance checklist shall be arranged in a columnar format. The first column shall list all devices listed in the equipment compliance booklet, the second column shall state the maintenance activity or state no maintenance required, the third column shall state the frequency of the maintenance activity, and the fourth column for additional comments or reference.

b. The recommended repair methods list shall be arranged in a columnar format and shall list all devices in the equipment data compliance booklet and state the guidance on recommended repair methods, either field repair, factory repair, or whole-item replacement.

c. The as-built equipment data booklet shall include the equipment compliance booklet and manufacturer supplied user manuals and information.

d. If the operation manual and the maintenance and repair manual are provided in a common volume, they shall be clearly differentiated and separately indexed.

1.7 MAINTENANCE AND SERVICE

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NOTE: Delete or modify this paragraph according to the project specific design requirements.
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Services, materials and equipment shall be provided as necessary to maintain the entire system in an operational state as specified for a period of one year after successful completion and acceptance of the Performance Verification Test. Impacts on facility operations shall be minimized.

1.7.1 Description of Work

The adjustment and repair of the system shall include the manufacturer's required adjustments of computer equipment, software updates, transmission equipment and instrumentation and control devices.

1.7.2 Personnel

Service personnel shall be qualified to accomplish work promptly and satisfactorily. The Government shall be advised in writing of the name of the designated service representative, and of any changes in personnel.

1.7.3 Scheduled Inspections

Two inspections shall be performed at six-month intervals and all work required shall be performed. Inspections shall be scheduled in [June and December] [_____]. These inspections shall include:

a. Visual checks and operational tests of equipment.

b. Fan checks and filter changes for control system equipment.

c. Clean control system equipment including interior and exterior surfaces.

d. Check and calibrate each field device. Check and calibrate 50 percent of the total analog points during the first inspection. Check and calibrate the remaining 50 percent of the analog points during the second major inspection. Certify analog test instrumentation accuracy to be twice that of the device being calibrated. Randomly check at least 25 percent of all digital points for proper operation during the first inspection. Randomly check at least 25 percent of the remaining digital points during the second inspection.

e. Run system software diagnostics and correct diagnosed problems.

f. Resolve any previous outstanding problems.

1.7.4 Scheduled Work

This work shall be performed during regular working hours, Monday through Friday, excluding legal holidays.

1.7.5 Emergency Service

The Government will initiate service calls when the system is not functioning properly. Qualified personnel shall be available to provide service to the system. A telephone number where the service supervisor can be reached at all times shall be provided. Service personnel shall be at the site within 24 hours after receiving a request for service. The control system shall be restored to proper operating condition within three calendar days after receiving a request for service.

1.7.6 Operation

Scheduled adjustments and repairs shall include verification of the control system operation as demonstrated by the applicable tests of the performance verification test.

1.7.7 Records and Logs

Dated records and logs shall be kept of each task, with cumulative records for each major component, and for the complete system chronologically. A continuous log shall be maintained for all devices. The log shall contain initial analog span and zero calibration values and digital points. Complete logs shall be kept and shall be available for inspection onsite, demonstrating that planned and systematic adjustments and repairs have been accomplished for the control system.

1.7.8 Work Requests

Each service call request shall be recorded as received and shall include the serial number identifying the component involved, its location, date and time the call was received, nature of trouble, names of the service personnel assigned to the task, instructions describing what has to be done, the amount and nature of the materials to be used, the time and date work started, and the time and date of completion. A record of the work performed shall be submitted within 5 days after work is accomplished.

1.7.9 System Modifications

Recommendations for system modification shall be submitted in writing. No system modifications, including operating parameters and control settings, shall be made without prior approval of the Government. Any modifications made to the system shall be incorporated into the operations and maintenance manuals, and other documentation affected.

1.7.10 Software

Updates to the software shall be provided for system, operating and application software, and operation in the system shall be verified.

Updates shall be incorporated into operations and maintenance manuals, and software documentation. There shall be at least one scheduled update near the end of the first year's warranty period, at which time the latest released version of the Contractor's software shall be installed and validated.

1.8 FACTORY TESTING

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NOTE: Factory testing requirements should be coordinated with the user. Extent of factory testing should be based on the size of the job and the user's needs.

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The Contractor shall assemble the factory test DDC system as specified and shall perform test to demonstrate that the performance of the system satisfies the requirements of this specification. Model numbers of equipment tested shall be identical to those to be delivered to the site. Original copies of data produced, including results of each test procedure during factory testing shall be delivered to the Government at the conclusion of testing, prior to Government approval of the test. The test results documentation shall be arranged so that commands, responses, and data acquired are correlated in a manner which will allow for logical interpretation of the data.

1.8.1 Factory Test Setup

The factory test setup shall include the following:

a. Central workstation/tester.

b. Printer.

c. DDC test set.

d. Portable workstation/tester.

e. Communication links of each type and speed including MODEMs.

f. Dial-up MODEM.

g. Software.

PART 2 PRODUCTS

2.1 GENERAL EQUIPMENT REQUIREMENTS

Units of the same type of equipment shall be products of a single manufacturer. Each major component of equipment shall have the manufacturer's name and address, and the model and serial number in a conspicuous place. Materials and equipment shall be standard products of a manufacturer regularly engaged in the manufacturing of such products, which are of a similar material, design and workmanship. The standard products shall have been in a satisfactory commercial or industrial use for two years prior to use on this project. The two years' use shall include applications of equipment and materials under similar circumstances and of similar size. The two years' experience shall be satisfactorily completed by a product which has been sold or is offered for sale on the commercial market through advertisements, manufacturers' catalogs, or brochures. Products having less than a two-year field service record will be acceptable if a certified record of satisfactory field operation, for not less than 6,000 hours exclusive of the manufacturer's factory tests, can be shown. The equipment items shall be supported by a service organization. Items of the same type and purpose shall be identical, including equipment, assemblies, parts and components. Automatic temperature controls shall be direct digital controls that will provide the required sequence of operation.

2.1.1 Electrical and Electronic Devices

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NOTE: Show the requirements for enclosures other than NEMA ICS 1 on the drawings. Use other than a NEMA ICS 1 if environment of Mechanical Room or other location of DDC panel warrants such a choice.

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Electrical, electronic, and electropneumatic devices not located within a DDC panel shall have a NEMA ICS 1 enclosure in accordance with NEMA 250 unless otherwise shown.

2.1.2 Standard Signals

Except for air distribution terminal unit control equipment, the output of all analog transmitters and the analog input and output of all DDC controllers shall be 4-to-20 mAdc signals. The signal shall originate from current-sourcing devices and shall be received by current-sinking devices.

2.1.3 Ambient Temperature Limits

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NOTE: When the equipment room will exceed a panel's environmental limits, locate the panel in a nearby air conditioned space.

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DDC panels shall have ambient condition ratings of 35 to 120 degrees F and 10 to 95 percent relative humidity, noncondensing. Devices installed outdoors shall operate within limit ratings of minus 35 to plus 150 degrees F. Instrumentation and control elements shall be rated for continuous operation under the ambient environmental temperature, pressure, humidity, and vibration conditions specified or normally encountered for the installed location.

2.1.4 Year 2000 Compliance

All equipment and software shall be Year 2000 compliant and shall be able to accurately process date/time data (including, but not limited to, calculating, comparing, and sequencing) from, into, and between the twentieth and twenty-first centuries, including leap year calculations, when used in accordance with the product documentation provided by the contractor, provided that all products (e.g. hardware, software, firmware) used in combination with other information technology, shall accurately process date/time data if other information technology properly exchanges date/time data with it.

2.2 TUBING

2.2.1 Copper

Copper tubing shall conform to ASTM B 88, ASTM B 88M and shall have sweat fittings and valves.

2.2.2 Stainless Steel

Stainless steel tubing shall conform to ASTM A 269 and shall have stainless steel compression fittings.

2.2.3 Plastic

Plastic tubing shall have barbed fittings and valves. Plastic tubing shall have the burning characteristics of linear low-density polyethylene tubing, shall be self-extinguishing when tested in accordance with ASTM D 635, shall have UL 94 V-2 flammability classification, and shall withstand stress cracking when tested in accordance with ASTM D 1693. Plastic-tubing bundles shall be provided with Mylar barrier and flame-retardant polyethylene jacket.

2.3 WIRING

2.3.1 Terminal Blocks

Terminal blocks shall be insulated, modular, feed-through, clamp style with recessed captive screw-type clamping mechanism, shall be suitable for rail mounting, and shall have end plates and partition plates for separation or shall have enclosed sides.

2.3.2 Control Wiring for 24-Volt Circuits

Control wiring for 24-volt circuits shall be 18 AWG minimum, stranded copper and shall be rated for 300-volt service.

2.3.3 Wiring for 120-Volt Circuits

Wiring for 120-volt circuits shall be 18 AWG minimum, stranded copper and shall be rated for 600-volt service.

2.3.4 Instrumentation Cable

Instrumentation cable shall be 18 AWG, stranded copper, single- or multiple-twisted, minimum 2 inch lay of twist, 100 percent shielded pairs, and shall have a 300-volt insulation. Each pair shall have a 20 AWG tinned-copper drain wire and individual overall pair insulation. Cables shall have an overall aluminum-polyester or tinned-copper cable-shield tape, overall 20 AWG tinned-copper cable drain wire, and overall cable insulation.

2.3.5 Transformers

Step down transformers shall be utilized where control equipment operates at lower than line circuit voltage. Transformers, other than transformers in bridge circuits, shall have primaries wound for the voltage available and secondaries wound for the correct control circuit voltage. Transformer shall be sized so that the connected load is 80 percent of the rated capacity or less. Transformers shall conform to UL 508 and NEMA ST 1.

2.4   ACTUATORS

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NOTE: The designer shall show pneumatic or electric actuators on the control system drawings, and shall choose between electric or electronic and pneumatic actuators based on an estimate of the life cycle cost. If the cost estimate determines that pneumatic actuators are cost-effective and compressed air is not available, the designer will specify a compressed air station and show pneumatic actuators. Positive positioners are not required for electric or electronic actuators. Electric or electronic actuators will be shown for terminal unit control systems.
****

Actuators shall be [pneumatic] [electric or electronic] as shown and shall be provided with mounting and connecting hardware. Electric or electronic actuators shall be used for variable air volume (VAV) air terminal units. Actuators shall fail to their spring-return positions on signal or power failure [,except that VAV terminal unit actuators may be of the floating type]. The actuator stroke shall be limited in the direction of power stroke by an adjustable stop. Actuators shall have a visible position indicator. Actuators shall smoothly open or close the devices to which they are applied and shall have a full stroke response time of 90 seconds or less. Electric actuators shall have an oil-immersed gear train. Electric or electronic actuators operating in series shall have an auxiliary actuator driver. Electric or electronic actuators used in sequencing applications shall have an adjustable operating range and start point. Pneumatic actuators shall be rated for 25 psig operating pressure except for high-pressure cylinder-type actuators.

2.4.1   Valve Actuators

****
NOTE: The designer will calculate the required close-off pressure rating for each valve actuator and show it on the drawings.
****

Valve actuators shall be selected to provide a minimum of 125 percent of the motive power necessary to operate the valve over its full range of operation.

2.4.2   Positive Positioners

Positive positioners are required for pneumatic actuators. Each positive positioner shall be a pneumatic relay with a mechanical feedback mechanism and an adjustable operating range and starting point.

2.5   AUTOMATIC CONTROL VALVES

****
NOTE: Calculate and show the required Kv (Cv) for each valve on the drawings.
****

Valves shall have stainless-steel stems and stuffing boxes with extended necks to clear the piping insulation. Unless otherwise stated, valves shall have globe style bodies. Valve bodies shall be designed for not less than 125 psig working pressure or 150 percent of the system operating pressure, whichever is greater. Valve leakage rating shall be 0.01 percent of rated Cv. Unless otherwise specified, bodies for valves 1-1/2 inches and smaller shall be brass or bronze, with threaded or union ends; bodies for 2 inch valves shall have threaded ends; and bodies for valves 2 to 3 inches shall be of brass, bronze or iron. Bodies for valves 2-1/2 inches and larger shall be provided with flanged-end connections. Valve Cv shall be within 100 to 125 percent of the Cv shown.

2.5.1 Butterfly Valve Assembly

Butterfly valves shall be threaded lug type suitable for dead-end service and modulation to the fully-closed position, with carbon-steel bodies and noncorrosive discs, stainless steel shafts supported by bearings, and EPDM seats suitable for temperatures from minus 20 to plus 250 degrees F. Valves shall have a manual means of operation independent of the actuator. The rated Cv for butterfly valves shall be the value Cv at 70% open (60 degrees open).

2.5.2 Two-Way Valves

Two-way modulating valves shall have equal-percentage characteristics.

2.5.3 Three-Way Valves

Three-way valves shall provide linear flow control with constant total flow throughout full plug travel.

2.5.4 Duct-Coil and Terminal-Unit-Coil Valves

Control valves with either flare-type or solder-type ends shall be provided for duct or terminal-unit coils. Flare nuts shall be furnished for each flare-type end valve.

2.5.5 Valves for Chilled-Water, Condenser-Water, and Glycol Service

Internal valve trim shall be bronze except that valve stems may be type 316 stainless steel. Valve Cv shall be within 100 to 125 percent of the Cv shown. Valves 4 inches and larger shall be butterfly.

2.5.6 Valves for Hot-Water and Dual Temperature Service

For hot water service below 250 degrees F and dual-temperature service, internal trim (including seats, seat rings, modulating plugs, and springs) of valves controlling water hotter than 210 degrees F shall be Type 316 stainless steel. Internal trim for valves controlling water 210 degrees F or less shall be brass or bronze. Nonmetallic parts of hot-water control valves shall be suitable for a minimum continuous operating temperature of 250 degrees F or 50 degrees F above the system design temperature, whichever is higher. Valves 4 inches and larger shall be butterfly valves.

2.5.7 Valves for Steam Service

Bodies for valves 4 inches and larger shall be iron. Internal valve trim shall be Type 316 stainless steel. Valve Cv shall be not less than shown nor greater than the Cv of the manufacturer's next larger size.

2.5.8 Valves for High-Temperature Hot-Water Service

For high-temperature hot water service above 250 Degrees F, valve bodies shall be rated ANSI Class 300, as specified in ASME B16.34. Valve and actuator combination shall be normally closed. Bodies shall be carbon steel, globe type with welded ends on valves 1 inch and larger. Valves smaller than 1 inch shall have socket-weld ends. Packing shall be virgin polytetrafluoroethylene (PTFE). Internal valve trim shall be Type 316 stainless steel. Valve Cv shall be within 100 to 125 percent of the Cv shown.

2.6 DAMPERS

****

NOTE: If the design of the HVAC system does not include smoke dampers, delete paragraph Smoke Dampers.

Check damper locations shown against the expected velocity profile to ensure that the maximum velocity of the profile (not average velocity) does not exceed the specified damper velocity limitations.

****

2.6.1 Damper Assembly

A single damper section shall have blades no longer than 48 inches and shall be no higher than 72 inches. Maximum damper blade width shall be 8 inches. Larger sizes shall be made from a combination of sections. Dampers shall be steel, or other materials where shown. Flat blades shall be made rigid by folding the edges. Blade-operating linkages shall be within the frame so that blade-connecting devices within the same damper section shall not be located directly in the air stream. Damper axles shall be 0.5 inch minimum, plated steel rods supported in the damper frame by stainless steel or bronze bearings. Blades mounted vertically shall be supported by thrust bearings. Pressure drop through dampers shall not exceed 0.04 inch water gauge at 1,000 feet per minute in the wide-open position. Frames shall not be less than 2 inches in width. Dampers shall be tested in accordance with AMCA 500.

2.6.2 Operating Links

Operating links external to dampers, such as crankarms, connecting rods, and line shafting for transmitting motion from damper actuators to dampers, shall withstand a load equal to at least twice the maximum required damper-operating force. Rod lengths shall be adjustable. Links shall be brass, bronze, zinc-coated steel, or stainless steel. Working parts of joints and clevises shall be brass, bronze, or stainless steel. Adjustments of crankarms shall control the open and closed positions of dampers.

2.6.3   Damper Types

Dampers shall be parallel-blade type.

2.6.3.1   Outside Air, Return Air, and Relief Air Dampers

Outside air, return air and relief air dampers shall be provided where shown. Blades shall have interlocking edges and shall be provided with compressible seals at points of contact. The channel frames of the dampers shall be provided with jamb seals to minimize air leakage. Dampers shall not leak in excess of 20 cfm per square foot at 4 inches water gauge static pressure when closed. Seals shall be suitable for an operating temperature range of minus 40 to plus 200 degrees F. Dampers shall be rated at not less than 2,000 feet per minute air velocity.

2.6.3.2   Mechanical and Electrical Space Ventilation Dampers

Mechanical and electrical space ventilation dampers shall be as shown. Dampers shall not leak in excess of 80 cfm square foot at 4 inches water gauge static pressure when closed. Dampers shall be rated at not less than 1,500 feet per minute air velocity.

2.6.3.3   Smoke Dampers

Smoke-damper and actuator assembly required per NFPA 90A shall meet the Class II leakage requirements of UL 555S. Dampers shall be rated at not less than 2000 fpm air velocity.

2.6.4   Damper End Switches

****

NOTE: If the HVAC system design includes smoke dampers in the return air and fan discharge, or other dampers requiring end switches, show the end switches on schematics and ladder diagrams.

****

Each end switch shall be a hermetically sealed switch with a trip lever and over-travel mechanism. The switch enclosure shall be suitable for mounting on the duct exterior and shall permit setting the position of the trip lever that actuates the switch. The trip lever shall be aligned with the damper blade.

2.7   SMOKE DETECTORS

****

NOTE: Duct detectors are intended to shut down air distribution fans and smoke dampers if provided. Each detector will be indicated on the schematic and associated ladder diagram. When duct smoke detectors which are remote from the associated fans are required, such as those required in air systems over 7 cubic meters/ second (15,000 cfm) serving more than one story, the location of all duct detectors shall be indicated on the plans as well as

on the schematic and ladder diagrams.

When the building is equipped with a fire alarm system, the detectors will be connected to the fire alarm control panel (FACP) for alarm initiation. Drawings will indicate wiring to the fire alarm control panel. For existing alarm systems, the designer must detail the connection to the FACP. Duct mounted smoke detectors will need auxiliary contacts to interface with HVAC Control Panel. Coordinate with Section 16721 FIRE DETECTION AND ALARM SYSTEM.

****

Duct smoke detectors shall be provided in supply and return air ducts in accordance with NFPA 90A. Duct smoke detectors shall conform to the requirements of UL 268A. Duct smoke detectors shall have perforated sampling tubes extended into the air duct. Detector circuitry shall be mounted in a metallic enclosure exterior to the duct. [Detectors shall have manual reset.] Detectors shall be rated for air velocities that include air flows between [500 and 4000] [_____] fpm. Detectors shall be powered from the [HVAC control panel.] [fire alarm control panel (FACP).] Detectors shall have two sets of normally open alarm contacts and two sets of normally closed alarm contacts. [Detectors shall be connected to the building fire alarm panel for alarm initiation.] A remote annunciation lamp and accessible remote reset switch shall be provided for duct detectors that are mounted eight feet or more above the finished floor and for detectors that are not readily visible. Remote lamps and switches as well as the affected fan units shall be properly identified in etched rigid plastic placards.

2.8 INSTRUMENTATION

2.8.1 Measurements

Transmitters shall be calibrated to provide the following measurements, over the indicated ranges, for an output of 4 to 20 mAdc:

a. Conditioned space temperature, from 50 to 85 degrees F.

b. Duct temperature, from 40 to 140 degrees F.

c. High-temperature hot-water temperature, from 200 to 500 degrees F.

d. Chilled-water temperature, from 30 to 100 degrees F.

e. Dual-temperature water, from 30 to 240 degrees F.

f. Heating hot-water temperature, from 50 to 250 degrees F.

g. Condenser-water temperature, from 30 to 130 degrees F.

h. Outside-air temperature, from minus 30 to 130 degrees F.

i. Relative humidity, 0 to 100 percent for space and duct high-limit applications.

j. Differential pressure for VAV supply-duct static pressure from 0 to 2.0 inches water gauge.

k. Pitot-tube air-flow measurement station and transmitter, from 0 to 0.1 inch water gauge for flow velocities of 700 to 1200 fpm, 0 to 0.25 inch water gauge for velocities of 700 to 1800 fpm, or 0 to 0.5 inch water gauge for velocities of 700 to 2500 fpm.

l. Electronic air-flow measurement station and transmitter, from 125 to 2500 fpm.

2.8.2 Temperature Instruments

2.8.2.1 Resistance Temperature Detectors (RTD)

Temperature sensors shall be 100 ohms 3- or 4-wire RTD. Each RTD shall be platinum with a tolerance of 0.54 degrees F at 32 degrees F with a temperature coefficient of resistance (TCR) of .00214 ohms/ohm/deg F and shall be encapsulated in epoxy, series 300 stainless steel, anodized aluminum, or copper. Each RTD shall be furnished with an RTD transmitter as specified, integrally mounted unless otherwise shown.

2.8.2.2 Continuous Averaging RTD

Continuous averaging RTDs shall have a tolerance of plus or minus 1.0 degree F at the reference temperature, and shall be of sufficient length to ensure that the resistance represents an average over the cross section in which it is installed. The sensing element shall have a bendable copper sheath. Each averaging RTD shall be furnished with an RTD transmitter to match the resistance range of the averaging RTD.

2.8.2.3 RTD Transmitter

The RTD transmitter shall match the resistance range of the RTD. The transmitter shall be a two-wire, loop powered device. The transmitter shall produce a linear 4-to-20 mAdc output corresponding to the required temperature measurement. The output error shall not exceed 0.1 percent of the calibrated measurement.

2.8.3 Relative Humidity Instruments

A relative-humidity instrument for indoor application shall have a measurement range from 0 to 100 percent relative-humidity and be rated for operation at ambient air temperatures within the range of 25 to 130 degrees F. It shall be capable of being exposed to a condensing air stream (100 percent RH) with no adverse effect to the sensor's calibration or other harm to the instrument. The instrument shall be of the wall-mounted or duct-mounted type, as required by the application, and shall be provided with any required accessories. Instruments used in duct high-limit applications shall have a bulk polymer resistive sensing element. Duct-mounted instruments shall be provided with a duct probe designed to protect the sensing element from dust accumulation and mechanical damage. The instrument (sensing element and transmitter) shall be a two-wire, loop-powered device and shall have an accuracy of plus or minus three percent of full scale within the range of 20 to 80 percent relative humidity. The instrument shall have a typical long-term stability of 1 percent or less drift per year. The transmitter shall convert the sensing element's output to a linear 4-20 mAdc output signal in proportion to the measured relative-humidity value. The transmitter shall include offset and span adjustments.

2.8.4 Electronic Airflow Measurement Stations and Transmitters

2.8.4.1 Stations

Each station shall consist of an array of velocity sensing elements and an air-flow straightener. Air-flow straightener shall be contained in a flanged sheet metal or aluminum casing. The velocity sensing elements shall be of the RTD or thermistor type, producing a temperature compensated output. The sensing elements shall be distributed across the duct cross section in the quantity and pattern specified by the published application data of the station manufacturer. The resistance to air flow through the airflow measurement station shall not exceed 0.08 inch water gauge at an airflow of 2,000 fpm. Station construction shall be suitable for operation at airflows of up to 5,000 fpm over a temperature range of 40 to 120 degrees F, and accuracy shall be plus or minus three percent over a range of 125 to 2,500 fpm. In outside air measurement or in low-temperature air delivery applications, the station shall be certified by the manufacturer to be accurate as specified over a temperature range of minus 20 to plus 120 degrees F. In outside air measurement applications,the air flow straightener shall be constructed of 1/8 inch aluminum honeycomb and the depth of the straightener shall not be less than 1.5 inches.

2.8.4.2 Transmitters

Each transmitter shall produce a linear, 4-to-20 mAdc, output corresponding to the required velocity pressure measurement. The transmitter shall be a two-wire, loop powered device. The output error of the transmitter shall not exceed 0.5 percent of the calibrated measurement.

2.8.5 Pitot Tube Airflow Measurement Stations and Transmitters

2.8.5.1 Stations

Each station shall contain an array of velocity sensing elements and straightening vanes inside a flanged sheet metal casing. The velocity sensing elements shall be of the multiple pitot tube type with averaging manifolds. The sensing elements shall be distributed across the duct cross section in the quantity and pattern specified by the published installation instructions of the station manufacturer. The resistance to air flow through the airflow measurement station shall not exceed 0.08 inch water gauge at an airflow of 2,000 fpm. Station construction shall be suitable for operation at airflows of up to 5,000 fpm over a temperature range of 40 to 120 degrees F, and accuracy shall be plus or minus three percent over a range of 500 to 2,500 fpm. This device will not be used if the required velocity measurement is below 700 fpm or for outside airflow measurements.

2.8.5.2 Transmitters

Each transmitter shall produce a linear 4-to-20 mAdc output corresponding to the required velocity pressure measurement. Each transmitter shall have a low range differential pressure sensing element. The transmitter shall be a two-wire, loop powered device. Sensing element accuracy shall be plus or minus one percent of full scale, and overall transmitter accuracy shall be plus or minus 0.25 percent of the calibrated measurement.

2.8.6 Differential Pressure Instruments

The instrument shall be a pressure transmitter with an integral sensing element. The instrument over pressure rating shall be 300 percent of the operating pressure. The sensor/transmitter assembly accuracy shall be plus or minus two percent of full scale. The transmitter shall be a two-wire, loop-powered device. The transmitter shall produce a linear 4-to-20 mAdc output corresponding to the required pressure measurement.

2.8.7 Thermowells

Thermowells shall be Series 300 stainless steel with threaded brass plug and chain, 2 inch lagging neck and extension type well. Inside diameter and insertion length shall be as required for the application.

2.8.8 Sunshields

****

NOTE: Show locations of the sunshields for the outside air temperature sensing elements on the drawings.

****

Sunshields for outside air temperature sensing elements shall prevent the sun from directly striking the temperature sensing elements. The sunshields shall be provided with adequate ventilation so that the sensing element responds to the ambient temperature of the surroundings. The top of each sunshield shall have a galvanized metal rainshield projecting over the face of the sunshield. The sunshields shall be painted white.

2.9 THERMOSTATS

Thermostat ranges shall be selected so that the setpoint is adjustable without tools between plus or minus 10 degrees F of the setpoint shown. Thermostats shall be electronic or electric.

2.9.1 Nonmodulating Room Thermostats

Contacts shall be single-pole double-throw (SPDT), hermetically sealed, and wired to identified terminals. Maximum differential shall be 5 degrees F. Room thermostats shall be enclosed with separate locking covers (guards).

2.9.2 Microprocessor Based Room Thermostats

Microprocessor based thermostats shall have built-in keypads for scheduling of day and night temperature settings. When out of the scheduling mode, thermostats shall have continuous display of time, with AM and PM indicator, continuous display of day of week, and either continuous display of room temperature with display of temperature setpoint on demand, or continuous display of temperature setpoint with display of room temperature on demand. In the programmable mode, the display shall be used for interrogating time program ON-OFF setpoints for all seven days of the week. The time program shall allow two separate temperature setback intervals per day. The thermostats shall have a means for temporary and manual override of the program schedule, with automatic program restoration on the following day. Thermostats shall have a replaceable battery to maintain the timing and maintain the schedule in memory for one year in the event of a power outage. Maximum differential shall be 2 degrees F. When used for heat pump applications, the thermostat shall have an emergency heat switch.

2.9.3 Modulating Room Thermostats

Modulating room thermostats shall have either one output signal, two output signals operating in unison, or two output signals operating in sequence, as required for the application. Each thermostat shall have an adjustable throttling range of 4 to 8 degrees F for each output. Room thermostats shall be enclosed with separate locking covers (guards).

2.9.4 Nonmodulating Capillary Thermostats and Aquastats

Each thermostat shall have a capillary length of at least 5 feet, shall have adjustable direct-reading scales for both setpoint and differential, and shall have a differential adjustable from 6 to 16 degrees F. Aquastats shall be of the strap on type, with 10 degrees F fixed differential.

2.9.5 Freezestats

Freezestats shall be manual reset, low temperature safety thermostats, with NO and NC contacts and a 20 foot element which shall respond to the coldest 18 inch segment.

2.9.6 Modulating Capillary Thermostats

Each thermostat shall have either one output signal, two output signals operating in unison, or two output signals operating in sequence, as required for the application. Thermostats shall have adjustable throttling ranges of 4 to 8 degrees F for each output.

2.9.7 Fan-Coil Unit Room Thermostats

****

NOTE: Edit the bracketed words depending on whether occupant adjustment capability is required for the room thermostat.

****

Fan-coil unit thermostats in personnel living spaces shall be of the low voltage type with locking covers. Electrical rating shall not exceed 2.5 amperes at 30 volts ac. Housing shall be corrosion resisting metal or molded plastic. Transformer and fan relay shall be provided for the proper operation of each thermostatic control system as necessary to suit the design of the control system using the thermostats specified below. Either separate heating thermostats and separate cooling thermostats or dual element heating cooling thermostats may be provided. Motor speed switches shall be provided for three-speed fan control.

2.9.7.1 Heating Thermostat

Fan-coil heating thermostats shall be provided with fixed heat anticipation and shall have a single-pole, single-throw (SPST) switch hermetically sealed and actuated by a bimetallic or bellows type element. Thermostats shall be provided with external temperature setting devices with a factory set maximum of [72] [68] degrees F. Heating thermostats shall have an adjustable range of at least 13 degrees below [72] [68] degrees F.

2.9.7.2 Cooling Thermostat

Fan-coil cooling thermostats shall be provided with fixed cooling anticipation heater and shall have a single-pole, single-throw (SPST) switch hermetically sealed and actuated by a bimetallic or bellows type element. Thermostats shall be provided with external temperature setting devices with a factory set minimum of 78 degrees F. Cooling thermostats shall have an adjustable range of at least 7 degrees above 78 degrees F.

2.9.7.3 Combination Thermostat

Fan coil unit combination heating-cooling thermostats shall be provided with separate temperature sensing elements for each system, and shall have a single-pole, single-throw (SPST) switch, hermetically sealed and actuated by a bimetallic or bellows type element. Each element shall operate switches to provide single stage control for heating and cooling. Scales and ranges shall be as specified for individual thermostats. Thermostats shall contain, or a subbase shall be provided which contains, selector switches for Heat-Off-Cool. A changeover controller providing automatic summer-winter changeover for thermostats by sensing the supplied fluid temperature shall be provided. A limited range heating-cooling dead band thermostat shall control cooling when temperature is above the upper setpoint and heating when temperature is below the lower setpoint and shall have a dead band, with no heating or cooling, when temperature is between the setpoints. Setpoint adjustment shall be concealed.

2.10 PRESSURE SWITCHES AND SOLENOID VALVES

2.10.1 Pressure Switches

Each switch shall have an adjustable setpoint with visible setpoint scale. Range shall be as shown. Differential adjustment shall span 20 to 40 percent of the range of the device.

2.10.2 Differential-Pressure Switches

Each switch shall be an adjustable diaphragm-operated device with two SPDT contacts, with taps for sensing lines to be connected to duct pressure fittings designed to sense air pressure. These fittings shall be of the angled-tip type with tips pointing into the air stream. The setpoint shall not be in the upper or lower quarters of the range and the range shall not be more than three times the setpoint. Differential shall be a maximum of 0.15 inch water gauge at the low end of the range and 0.35 inch water gauge at the high end of the range.

2.10.3 Pneumatic Electric (PE) Switches

Each switch shall have an adjustable setpoint range of 3 to 20 psig with a switching differential adjustable from 2 to 5 psig. The switch action shall be SPDT.

2.10.4 Solenoid-Operated Pneumatic (EP) Valves

Each valve shall have three-port operation: common, normally open, and normally closed. Each valve shall have an outer cast aluminum body and internal parts of brass, bronze, or stainless steel. The air connection shall be a 3/8 inch NPT threaded connection. Valves shall be rated for 50 psig when used in a control system that operates at 25 psig or less, or 150 psig when used in a control system that operates in the range of 25 to 100 psig.

2.11 INDICATING DEVICES

2.11.1 Thermometers

Mercury shall not be used in thermometers.

2.11.1.1 Piping System Thermometers

Piping system thermometers shall have brass, malleable iron or aluminum alloy case and frame, clear protective face, permanently stabilized glass tube with indicating-fluid column, white face, black numbers, and a 9 inch scale. Thermometers for piping systems shall have rigid stems with straight, angular, or inclined pattern.

2.11.1.2 Piping System Thermometer Stems

Thermometer stems shall have expansion heads as required to prevent breakage at extreme temperatures. On rigid-stem thermometers, the space between bulb and stem shall be filled with a heat-transfer medium.

2.11.1.3 Nonaveraging Air-Duct Thermometers

Air-duct thermometers shall have perforated stem guards and 45-degree adjustable duct flanges with locking mechanism.

2.11.1.4 Averaging Air-Duct Thermometers

Averaging thermometers shall have a 3-1/2 inch (nominal) dial, with black legend on white background, and pointer traveling through a 270-degree arc.

2.11.1.5 Accuracy

Thermometers shall have an accuracy of plus or minus one percent of scale range. Thermometers shall have a range suitable for the application.

2.11.2 Pressure Gauges

Gauges shall be 2 inch (nominal) size, back connected, suitable for field or panel mounting as required, shall have black legend on white background, and shall have a pointer traveling through a 270-degree arc. Accuracy shall be plus or minus three percent of scale range. Gauges shall meet requirements of ASME B40.1.

2.11.2.1 Pneumatic Actuator Gauges

Gauges for indicating signal output to pneumatic actuators shall have an outer scale of 3 to 15 psig in 1 psig graduations.

2.11.2.2 Air Storage Tank and Filter and Dryer Gauge

Gauges for air storage tanks or for use before and after dirt and oil filters or dryers, shall have a scale of 0 to 160 psig with 2 psig graduations.

2.11.2.3 Hydronic System Gauges

****
NOTE: Show the required ranges and dial graduations for these gauges where they are applied.
****

Gauges for hydronic system applications shall have ranges and graduations as shown.

2.11.3 Low Differential Pressure Gauges

Gauges for low differential pressure measurements shall be a minimum of 3.5 inch (nominal) size with two sets of pressure taps, and shall have a diaphragm-actuated pointer, white dial with black figures, and pointer zero adjustment. Gauges shall have ranges and graduations as shown. Accuracy shall be plus or minus two percent of scale range.

2.12 CONTROL DEVICES AND ACCESSORIES

2.12.1 Relays

Control relay contacts shall have utilization category and ratings selected for the application, with a minimum of two sets of contacts (two normally open, two normally closed) enclosed in a dustproof enclosure. Relays shall be rated for a minimum life of one million operations. Operating time shall be 20 milliseconds or less. Relays shall be equipped with coil transient suppression devices to limit transients to 150 percent of rated coil voltage. Time delay relays shall be 2PDT with eight-pin connectors, dust cover, and a matching rail-mounted socket. Adjustable timing range shall be 0 to 5 minutes. Power consumption shall not be greater than three watts.

2.12.2 Current to Pneumatic (IP) Transducers

The transducers shall be two-wire current-to-pressure transmitters that convert a 4-to-20 mAdc input signal to a 3 to 15 psig, or a 15 to 3 psig, pneumatic output, with a conversion accuracy of plus or minus two percent of full scale, including linearity and hysteresis. Input impedance shall not exceed 250 ohms. Air consumption shall not be greater than 0.25 scfm.

2.12.3 Joule or Watthour Meters

Watthour meters shall be in accordance with ANSI C12.1 and have pulse initiators for remote monitoring of Watthour consumption. Pulse initiator shall consist of form C contacts with a current rating not to exceed two amperes and voltage not to exceed 500 V, with combinations of VA not to exceed 100 VA, and a life rating of one billion operations. Meter sockets shall be in accordance with ANSI C12.1.

2.12.4 Joule or Watthour Meters with Demand Register

Meters shall be in accordance with ANSI C12.1 and shall have pulse initiators for remote monitoring of Watthour consumption and instantaneous demand. Pulse initiators shall consist of form C contacts with a current rating not to exceed two amperes and voltage not to exceed 500 V, with combinations of VA not to exceed 100 VA, and a life rating of one billion operations. Meter sockets shall be in accordance with ANSI C12.1

2.12.5 Joule or Watthour Transducers

Watthour transducers shall have an accuracy of plus or minus 0.25 percent for kW and kWh outputs from full lag to full lead power factor. Input ranges for kW and kWh transducers shall be selectable without requiring the changing of current or potential transformers. The output shall be 4 to 20 mAdc.

2.12.6 Current Sensing Relays

Current sensing relays shall provide a normally-open contact rated at a minimum of 50 volts peak and 1/2 ampere or 25 VA, noninductive. There shall be a single hole for passage of current carrying conductors. The devices shall be sized for operation at 50 percent rated current based on the connected load. Voltage isolation shall be a minimum of 600 volts.

2.12.7 Power-Line Conditioners (PLC)

****

NOTE: A power line conditioner should be included only under certain/extreme circumstances as recommended by an electrical designer.

Indicate the line side voltage available to the Contractor for each Direct Digital Control (DDC) device referenced in paragraph DIRECT DIGITAL CONTROL (DDC) HARDWARE.

****

Power line conditioners shall be furnished for each DDC panel. The PLCs shall provide both voltage regulation and noise rejection. The PLCs shall be of the ferro-resonant design, with no moving parts and no tap switching, while electrically isolating the secondary from the power-line side. The PLCs shall be sized for 125 percent of the actual connected kVA load. Characteristics of the PLC shall be as follows:

a. At 85 percent load, the output voltage shall not deviate by more than plus or minus one percent of nominal when the input voltage fluctuates between minus 20 percent to plus 10 percent of nominal.

b. During load changes of zero to full load, the output voltage shall not deviate by more than plus or minus three percent of nominal voltage. Full correction of load switching disturbances shall be accomplished within five cycles, and 95 percent correction shall be accomplished within two cycles of the onset of the disturbance.

c. Total harmonic distortion shall not exceed 3-1/2 percent at full load.

2.13 COMPRESSED AIR STATIONS

****

NOTE: The designer will estimate the required control air consumption to calculate the required motor horsepower of the control air compressor and coordinate with the electrical designer.

For hospitals and critical installations, a standby compressor will be provided. For all other applications, the portion covering standby compressor will be deleted. For hospitals, delete the Contractor option permitting the use of polyethylene tubing in lieu of copper.

Indicate on the drawings the locations where metallic raceway or electric metallic tubing is not required for protection of nonmetallic tubing.

****

2.13.1 Air Compressor Assembly

The air compressor shall be a high pressure compressing unit with electric motor. The compressor shall be equipped with a motor with totally enclosed belt guard, an operating-pressure switch, safety relief valves, gauges, intake filter and intake silencer, and combination type magnetic starter with undervoltage protection and thermal-overload protection for each phase, and shall be supported by a steel base mounted on an air storage tank. The air compressor shall provide the compressed air required for control operation while operating not more than one-third of the time. The air storage tank shall be fabricated for a working pressure of not less than 200 psig, and constructed and certified in accordance with ASME BPVC SEC VIII D1. The tank shall be of sufficient volume so that no more than six compressor starts per hour are required with the starting pressure switch differential set at 20 psig. The tank shall be provided with an automatic condensate drain trap with manual override feature. A second (duplex arrangement) compressor of capacity equal to the primary compressor shall be provided, with interlocked control to provide automatic changeover upon malfunction or failure of either compressor. A manual selector switch shall be provided to index the lead compressor including the automatic changeover.

2.13.2 Compressed Air Station Specialties

2.13.2.1 Refrigerated Dryer, Filters and, Pressure Regulator

A refrigerated dryer shall be provided in the air outlet line of the air storage tank. The dryer shall be of the size required for the full delivery capacity of the compressor. The air shall be dried at a pressure of not less than 70 psig to a temperature not greater than 35 degrees F. The dryer shall be provided with an automatic condensate drain trap with manual override feature. The refrigerant used in the dryer shall be one of the fluorocarbon gases and have an Ozone Depletion Potential of not more than 0.05. A five micron prefilter and coalescing-type 0.03 micron oil removal filter with shut-off valves shall be provided in the dryer discharge. Each filter bowl shall be rated for 150 psig maximum working pressure. A pressure regulator, with high side and low side pressure gauges, and a safety valve shall be provided downstream of the filter. Pressure regulators of the relieving type shall not be used.

2.13.2.2 Flexible Pipe Connections

The flexible pipe connectors shall be designed for 150 psig and 250 degrees F service, and shall be constructed of rubber, tetrafluoroethylene resin, or braided corrosion-resistant steel, bronze, monel, or galvanized steel. The connectors shall be suitable for the service intended and may have threaded or soldered ends. The length of the connectors shall be as recommended by the manufacturer for the service intended.

2.13.2.3 Vibration Isolation Units

The vibration isolation units shall be standard products with published loading ratings, and shall be single rubber-in-shear, double rubber-in-shear, or spring type.

2.13.2.4 Compressed Air Piping

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NOTE: Delete protective sheath for nonmetallic tubing in concealed, accessible areas not subject to abuse.

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Control air delivered to the system shall conform to ISA S7.0.01. Air lines for pneumatic controls shall be seamless copper tubing or nonmetallic tubing. Air lines shall be concealed except in mechanical rooms and other areas where other tubing and piping is exposed. Air lines in exposed and concealed locations, free standing or enclosed in the conduit or other protective coverings, shall be run parallel to the building lines and shall be adequately supported from the building structure, at least every 6 feet horizontally and every 8 feet vertically. Copper tubing shall be hard-drawn in exposed areas and either hard-drawn or annealed in concealed areas. Only tool-made bends shall be used. Fittings for copper tubing shall be brass or copper solder joint type except at connections to apparatus, where fittings shall be brass compression type. Nonmetallic tubing shall be compounded from polyethylene, meeting the stress crack test of ASTM D 1693. Nonmetallic individual tube polyethylene or multitube instrument tubing bundle shall be classified as flame retardant under UL 94. The polyethylene material shall be rated as self-extinguishing when tested in accordance with ASTM D 635. Nonmetallic tubing shall be run within covered rigid metallic raceway, rigid conduit or electric metallic tubing except as indicated. Single nonmetallic tubing in a protective sheath, run parallel to the building lines and supported as indicated above, may be used above accessible ceilings and in other concealed but accessible locations. Air lines concealed in walls shall be hard-drawn copper tubing or nonmetallic tubing in rigid conduit. Terminal single lines shall be hard-drawn copper tubing, except when the run is less than 12 inches in length, flexible polyethylene may be used. Nonmetallic tubing will not be used for applications where the tubing could be subjected to a temperature exceeding 130 degrees F. Except in walls and exposed locations, nonmetallic multitube instrument tubing bundle without conduit or metallic raceway protection, may be used where a number of air lines run to the same points, provided the multitube bundle is enclosed in a protective sheath, is run parallel to the building lines and is adequately supported as indicated above. Air lines shall be tested periodically for leaks during installation. Air lines shall be purged of dirt, impurities and moisture before connecting to the control equipment. Fittings for nonmetallic tubing shall be for instrument service and may be brass or acetal resin of the compression or barbed push-on type. Air lines shall be number coded or color coded and keyed to the submittal drawings for future identification and servicing the control system.

2.14 DIRECT DIGITAL CONTROL (DDC) HARDWARE

All functions, constraints, data base parameters, operator developed programs and any other data shall be downloadable from a portable workstation/tester [or the central workstation/tester] to network control panels, RIU's, universal programmable controllers, and unitary controllers. Download shall be accomplished through both the primary network and the local DDC portable workstation/tester port.

2.14.1 Network Control Panel

Network control panels shall be microcomputer-based with sufficient memory provided to perform all specified and shown network control panel functions and operations, including spare capacity for all spares and its I/O functions specified. Each network control panel and remote I/O units (RIU) shall have a minimum of 10% of its I/O functions as spare capacity but not less than 2 of each type used in each. The type of spares shall be in the same proportion as the implemented I/O functions on the panel, but in no case shall there be less than two spare points of each type. The panel I/O functions shall be furnished complete, with no changes or additions necessary to support implementation of spare functions. Output relays associated with digital signals shall be considered part of the I/O function, whether physically mounted in the enclosure or separately mounted. Implementation of spare points shall necessitate only providing the additional field sensor or control device, field wiring including connection to the system, and point definition assignment by the operator using the central workstation/tester or portable workstation/tester. The panel shall contain all necessary I/O functions to connect to field sensors and control panels. I/O function operation shall be fully supervised to detect I/O function failures. Network control panels shall operate in an independent stand-alone mode, which is defined as all network control panel operations performed by the network control panel without any continuing input from other Direct digital controls or portable workstation/tester. The network control panel shall be capable of controlling a mix of at least 32 RIUs, unitary controllers, and universal programmable controllers.

2.14.1.1 Integral Features

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NOTE: Items e. and f. are not needed for all applications. The cost and benefit must be considered along with the users needs to determine whether or not to require them.

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The network control panel shall include:

a. Main power switch.

b. Power on indicator.

c. Portable workstation/tester port, connector, and if necessary power supply.

d. Manufacturers control network port.

e. On-Off-Auto switches for each DO which controls a device. These switches shall be mounted in the field panel, with the exception of motors, for which the switch shall be mounted at the motor control center. On-Off-Auto switches are not required for DO associated with a status or alarm such as pilot lights. The status of these switches shall be available to the panel for further processing.

f. Minimum-Maximum-Auto switches, or Auto-Manual switches with manual output override, for each AO. The status of these shall be available to the panel for further processing.

g. An intrusion detection device, connected as an alarm.

2.14.1.2 Communication Interfaces

The following communication capabilities shall function simultaneously.

a. Manufacturers Control Network. Manufacturers control network communications interfaces for each data transmission systems (DTS) circuit between network control panels and RIUs, unitary controllers, and universal programmable controllers, shall be provided. Communication interfaces shall be provided between each network control panel and associated I/O functions. The DTS will provide for transmission speeds necessary to comply with performance requirements specified. DTS equipment shall be installed in the network control panel enclosure.

b. Portable Workstation/Tester Port. A communications port for interfacing to a portable workstation/tester shall be provided. Network control panel workstation/tester port other than RS-232,shall be converted to RS-232, including cabling and power supply, and shall be permanently installed in the panel.

c. Primary Network Port. The network control panel shall either have a built in primary network Port or be capable of accepting a primary network port expansion card for future networking to a base wide utility monitoring and control system (UMCS). The primary network port expansion card shall be either Ethernet (IEEE802.3) or ARCNET.

2.14.1.3 Memory and Real Time Clock (RTC) Backup

The network control panel memory and real time clock functions shall continue to operate for a minimum of 72 hours in the event of a power failure. If rechargeable batteries are provided, automatic charging of batteries shall be provided. Whenever a either a permanent workstation/tester or portable workstation/tester is monitoring the network control panel, a low battery alarm message shall be sent to it.

2.14.1.4 Duplex Outlet

A single phase, 120 Vac electrical service outlet for use with test equipment shall be furnished either inside or within 6 feet of the network control panel enclosure.

2.14.1.5 Locking Enclosures

Locking type mounting cabinets with common keying shall be furnished for each network control panel.

2.14.1.6 Failure Mode

Upon failure of the network control panel, either due to failure of the network control panel hardware or of the manufacturers control network, the network control panel shall revert to the failure mode as shown.

a. Manufacturers Control Network Failure: Upon failure of the manufacturers control network, the network control panel shall operate in an independent stand-alone mode.

b. Network Control Panel Hardware Failure: Upon failure of the network control panel hardware, the network control panel shall cease operation and stop communications with other network control panels, RIUs, unitary controllers and universal programmable controllers connected to the affected network control panel. The affected network control panel shall respond to this failure as specified and shown.

2.14.2 RIU

The RIU shall be functionally a part of the network control panel as specified, but may be remotely located from the network control panel and communicate over a dedicated communication circuit. When remotely located, the I/O functions shall be subject to the same requirements as for the network control panel hardware. RIUs shall be used to connect remote inputs and outputs to a network control panel and shall contain all necessary I/O functions to connect to field sensors and control devices. RIU operation shall be fully supervised by the network control panel to detect failures. Each RIU shall have a minimum of 10 % of its I/O functions as spare capacity. The type of spares shall be in the same proportion as the implemented I/O functions on the RIU, but in no case shall there be less than two spare points of each type. The RIU shall be furnished complete, with no changes or additions necessary to support implementation of spare functions. Output relays associated with digital signals shall be considered part of the I/O function, whether physically mounted in the enclosure or separately mounted. Implementation of spare points by others shall require only providing the additional field sensor or control device, field wiring including connection to the system, and point definition assignment by the operator. The RIU shall either report the status of all connected points on each scan, or report the status of all points which have changed state or value since the previous scan.

2.14.2.1 Integral Features

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NOTE: Items e. and f. may not be necessary or desirable for all applications due the significant added cost. This requirement should therefore be evaluated before being included.

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The RIU shall include:

a. Main power switch.

b. Power on indicator.

c. Portable workstation/tester port, connector, and if necessary power supply.

d. Manufacturers control network port.

e. On-Off-Auto switches for each DO which controls a device. These switches shall be mounted in the RIU, with the exception of motors, for which the switch shall be mounted at the motor control center. On-Off-Auto switches are not required for DO associated with a status or alarm such as pilot lights. The status of these switches shall be available to the RIU for further processing.

f. Minimum-Maximum-Auto switches, or Auto-Manual switches with manual output override, for each AO. The status of these shall be available to the panel for further processing.

g. An intrusion detection device, connected as an alarm.

2.14.2.2 Duplex Outlet

A single phase, 120 Vac electrical service outlet for use with test equipment shall be furnished either inside or within 6 feet of the RIU.

2.14.2.3 Locking Enclosures

Locking type mounting cabinets with common keying shall be furnished for each RIU.

2.14.2.4 Failure Mode

Upon failure of the RIU, either due to failure of the RIU hardware or of the DTS, the RIU shall revert to the failure mode shown.

2.14.3 Universal Programmable Controller (UPC)

The universal programmable controller shall be a microprocessor based controller designed and programmed to control and monitor systems as shown. Resident programs shall be contained in reprogramable nonvolatile memory. Each universal programmable controller shall contain necessary power supplies, transformers, memory, I/O functions and communications interfaces necessary to perform its required functions and to provide control and monitoring of connected equipment and devices. It shall contain all necessary I/O functions to connect to field sensors and controls. I/O operation shall be fully supervised to detect I/O function failures. It shall provide for operation as a device connected to the system via the manufacturers control network.

2.14.3.1 Integral Features

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NOTE: Items f. and g. are not needed for all applications. The cost and benefit must be considered along with the users needs to determine whether or not to require them.

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The universal programmable controller shall include as a minimum:

a. Main power switch.

b. Power on indicator.

c. Portable workstation/tester port, connector, and if necessary power supply.

d. Manufacturers control network port.

e. I/O functions

(1) 8 DI

(2) 4 DO

(3) 8 AI

(4) 4 AO

(5) 1 PA

f. On-Off-Auto switches for each DO which controls a device. These switches shall be mounted in the universal programmable controller, with the exception of motors, for which the switch shall be mounted at the motor control center. On-Off-Auto switches are not required for DO associated with a status or alarm such as pilot lights. The status of these switches shall be available to the panel for further processing.

g. Minimum-Maximum-Auto switches, or Auto-Manual switches with manual output override, for each AO. The status of these shall be available to the panel for further processing.

2.14.3.2 Communication Interfaces

The UPC shall have the following communication capabilities which shall function simultaneously.

a. Manufacturers Control Network. The manufacturers control network communications interface for a data transmission systems (DTS) circuit between the UPC and a network control panels shall be provided. The DTS will provide for transmission speeds necessary to comply with performance requirements specified. DTS equipment shall be installed in the UPC Panel enclosure.

b. Portable Workstation/Tester Port. A communications port for interfacing to a portable workstation/tester shall be provided. A UPC workstation/tester port other than RS-232, shall be converted to RS-232, including cabling and power supply, and shall be permanently installed in the panel.

2.14.3.3 Memory and RTC Backup

The UPC memory and real time clock functions shall continue to operate for a minimum of 72 hours in the event of a power failure. If rechargeable batteries are provided, automatic charging of batteries shall be provided.

Whenever a either a permanent workstation/tester or portable workstation/tester is monitoring the network control panel, a low battery alarm message shall be sent to it.

2.14.3.4 Specific Requirements

Each universal programmable controller shall be accessible for purposes of application selection, control parameters, set point adjustment, and monitoring from any DDC controller connected to the same manufacturers control network as the universal programmable controller. This shall be done using a portable workstation/tester connected to a portable workstation/tester port either directly or via modem.

2.14.3.5 Locking Enclosures

Locking type mounting cabinets with common keying shall be furnished for each enclosure.

2.14.3.6 Failure Mode

Upon failure of the universal programmable controller, it shall revert to the failure mode of operation as shown.

2.14.4 Unitary Controller

The unitary controller shall be a microprocessor based, stand-alone, dedicated purpose controller, communicating with the network control panel, designed and programmed to control air distribution system mixing boxes, terminal units, heat pumps, fan coil units, self-contained DX units or VAV boxes as shown. Each unitary controller shall contain resident programs in nonvolatile memory for each specific application implemented. Each unitary controller shall contain necessary power supplies, transformers, memory, I/O functions and communications interfaces necessary to perform its required functions and to provide control and monitoring of connected equipment and devices. It shall contain all necessary I/O functions to connect to field sensors and controls. I/O operation shall be fully supervised to detect I/O function failures and shall provide for operation as a device connected to the network control panel via the manufacturers control network.

2.14.4.1 Integral Features

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NOTE: Items f. and g. are not needed for all applications. The cost and benefit must be considered along with the users needs to determine whether or not to require them.

****

The unitary controller shall include:

a. Main power switch.

b. Power on indicator.

c. Portable workstation/tester port, connector, and power supply.

d. Manufacturers control network port.

e. All I/O functions required to implement the requirements as shown.

f. On-Off-Auto switches for each DO which controls a device. These switches shall be mounted in the field panel, with the exception of motors, for which the switch shall be mounted at the motor control center. On-Off-Auto switches are not required for DO associated with a status or alarm such as pilot lights. The status of these switches shall be available to the panel for further processing.

g. Minimum-Maximum-Auto switches, or Auto-Manual switches with manual output override, for each AO. The status of these shall be available to the panel for further processing.

2.14.4.2 Communication Interfaces

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NOTE: Item b. below may not be needed for all applications. The cost and benefit must be considered along with the users needs to determine whether or not to require it.

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The unitary controller shall have the following communication capabilities which shall function simultaneously.

a. Manufacturers Control Network. The manufacturers control network communications interface for a data transmission systems (DTS) circuit between the unitary controller and a network control panel shall be provided. The DTS will provide for transmission speeds necessary to comply with performance requirements specified. DTS equipment shall be installed in the unitary control panel enclosure.

b. Portable Workstation/Tester Port. A communications port for interfacing to a portable workstation/tester shall be provided. A unitary controller workstation/tester port other than RS-232, shall be converted to RS-232, including cabling and power supply, and shall be permanently installed in the panel. For unitary controller applications where the controller is not mounted in an enclosure, such as for fan-coil units or VAV terminal units, a portable conversion device for an RS-232 connection to the portable workstation/tester may be provided.

2.14.4.3 Specific Requirements

Unitary controller components for new air distribution terminal units shall be furnished to the air distribution terminal unit manufacturer for factory mounting and calibration. Existing air distribution terminal units shall be controlled by field installed unitary controllers.

a. Accessibility and Interfaces: Each unitary controller shall be accessible for purposes of application selection, control parameters, set point adjustment, and monitoring using a portable workstation/tester connected to the manufacturers control network. They shall also be accessible with a portable workstation/tester connected to the unitary controller portable workstation/tester port.

b. Air Distribution Terminal Unit Controls - Pressure Independent: Controls shall consist of a transducer for connection to the velocity-sensing device provided by the terminal unit supplier in the primary air entering the terminal unit, a room temperature sensor, a damper actuator, and an adjustable microprocessor-based controller. [[The room temperature sensor shall have occupant setpoint adjustment and temperature display, timed override of unoccupied mode, and a communication port] [_____].] The controller shall operate the damper for cooling and heating and provide control outputs for duct heating coil if applicable. This controller capability shall allow the sequencing of the damper and the heating coil to maintain conditions in the space.

c. Air Distribution Terminal Unit Controls - Pressure Independent with Recirculating Fan: Controls for pressure-independent boxes with recirculating fans shall consist of a transducer for connection to the velocity-sensing device provided by the terminal unit supplier in the primary air entering the terminal unit, a room temperature sensing element, a damper actuator, an adjustable microprocessor-based terminal unit controller, and a switch to operate the recirculation fan, provided by the terminal unit supplier. [[The room temperature sensor shall have occupant setpoint adjustment and temperature display, timed override of unoccupied mode, and a communication port] [_____].] The controller shall operate the damper for cooling and shall provide outputs for controlling the recirculation fan and duct heating coil in sequence for heating.

d. Air Distribution Terminal Unit Damper Actuator: Air distribution terminal unit damper actuator shall open or close the device to which it is connected within 60 seconds. [[The damper actuator shall utilize spring return to fail to the position shown on loss of power or control signal] [_____].]

2.14.4.4 Failure Mode

Upon failure of the unitary controller, it shall revert to the failure mode of operation as shown.

2.14.5 Chiller Control Panel

Chiller control panel shall be microprocessor-based and shall provide, both locally and through the Manufacturers Control Network, the control, monitoring, and safety equipment functions provided by the chiller manufacturer's control panel(s) (two communications ports total). The chiller control panel instrumentation and control ranges and accuracies shall match those of the chiller manufacturer's control devices. The chiller panel shall have a communication port for interface to a Portable Workstation/Tester through either the Manufacturers Control Network or modem for chiller(s) start/stop, chilled water temperature reset, and monitoring of chiller operating status, alarms, and power consumption.

2.14.6 Boiler Control Panel

Boiler control panel shall be microprocessor-based and shall provide, both locally and through the Manufacturers Control Network, the control, monitoring, and safety equipment functions provided by the boiler manufacturer's control panel(s) (two communications ports total). The boiler control panel instrumentation and controls ranges and accuracies shall match those of the boiler manufacturer's control devices. The boiler panel shall have a communication port for interface to a Portable

Workstation/Tester through either the Manufacturers Control Network or modem for boiler(s) and start/stop, boiler water temperature reset, and monitoring of boiler operating status, alarms.

2.14.7 I/O Functions

2.14.7.1 DDC Hardware I/O Functions

I/O Functions shall be provided as part of the DDC system and shall be in accordance with the following:

a. The analog input (AI) function shall monitor each analog input, perform A-to-D conversion, and hold the digital value in a buffer for interrogation. The A-to-D conversion shall have a minimum resolution of 10 bits plus sign. Signal conditioning shall be provided for each analog input. Analog inputs shall be individually calibrated for zero and span, in hardware or in software. The AI shall incorporate common mode noise rejection of 50 dB from 0 to 100 Hz for differential inputs, and normal mode noise rejection of 20 dB at 60 Hz from a source impedance of 10,000 ohms. Input ranges shall be within the range of 4-to-20 mAdc.

b. The analog output (AO) function shall accept digital data, perform D-to-A conversion, and output a signal within the range of 4-to-20 mAdc. D-to-A conversion shall have a minimum resolution of eight bits plus sign. Analog outputs shall be individually calibrated for zero and span. Short circuit protection on voltage outputs and open circuit protection on current outputs shall be provided. [[An individual gradual switch for manual override of each analog output and means of physically securing access to these switches shall be provided. Each AO shall have a three-position switch for selection of the DDC control signal, no control, or a locally generated control signal for connection to the controlled device. Feedback shall be provided to the system as to the status of the output (manual control or automatic). Switches for pneumatic control outputs shall provide a connection for an externally generated pneumatic signal. All switches shall be either of a key operated design with the same keying system used for other outputs or otherwise suitably protected from unauthorized access] [_____].]

c. The digital input (DI) function shall accept on-off, open-close, or other change of state (two state data) indications. Isolation and protection against an applied steady-state voltage up to 180 Vac peak shall be provided.

d. The digital output (DO) function shall provide contact closures for momentary and maintained operation of output devices. Closures shall have a minimum duration of 0.1 second. DO relays shall have an initial breakdown voltage between contacts and coil of at least 500 V peak. Electromagnetic interference suppression shall be furnished on all output lines to limit transients to nondamaging levels. Protection against an applied steady-state voltage up to 180 Vac peak shall be provided. Minimum contact rating shall be one ampere at 24 Vac. [[Key locked HOA switches shall be provided for manual override of each digital output. Feedback shall be provided to the system as to the status of the output (manual control or automatic). Switches shall be common keyed] [_____].]

e. The pulse accumulator function shall have the same characteristics as the DI. In addition, a buffer shall be provided to totalize pulses and allow for interrogation by the DDC system. The pulse accumulator shall accept rates up to 20 pulses per second. The totalized value shall be reset to zero upon operator's command.

f. Signal conditioning for sensors shall be provided as specified.

g. The binary coded decimal (BCD) function: The BCD function shall have the same characteristics as the DI, except that, in addition, a buffer shall be provided to totalize inputs and allow for interrogation by the network control panel. The BCD function shall have 16-channel optically isolated buffered inputs to read four digit numbers. The BCD function shall accumulate inputs at rates up to 10 inputs per second.

2.14.7.2 Failure Mode

Upon failure of the I/O function, including data transmission failure, logic power supply failure, DDC processor malfunction, software failure, interposing relay power failure, or any other failure which prevents stand alone operation of any DDC normally capable of stand alone operation, connected outputs shall be forced to the failure mode shown.

2.14.8 Portable Workstation/Tester

A portable workstation/tester shall be provided and shall be able to connect to any DDC hardware. The portable workstation/tester shall consist of a portable computer with a nominal 10 inch active color matrix liquid crystal display, capable of displaying up to 256 colors at a minimum resolution of 640 X 480 pixels, an external VGA monitor port, 32 bit microprocessor operating at a minimum of 100 MHZ. The portable workstation/tester shall have, as a minimum, a 1200 MB hard drive, 16 megabytes of memory, integral pointing device, serial and parallel ports, color VGA video port for an external color monitor, 3.5 inch floppy disk drive, modem, PCMCIA type 3 slot, rechargeable battery, battery charger and 120 Vac power supply. It shall include carrying case, extra battery, charger and a compatible network adapter. The workstation/tester shall:

a. Run DDC diagnostics.

b. Load all DDC memory resident programs and information, including parameters and constraints.

c. Display any AI, DI, AO, DO, or PA point in engineering units for analog points or status for digital points.

d. Control any AO or DO.

e. Provide an operator interface, contingent on password level, allowing the operator to use full English language words and acronyms, or an object oriented graphical user interface.

f. Display database parameters.

g. Modify database parameters.

h. Accept DDC software and information for subsequent loading into a specific DDC. Provide all necessary software and hardware required to support this function, including an EIA ANSI/EIA/TIA-232-F port.

i. Disable/enable each DDC.

j. Perform all workstation functions as specified.

2.14.9 Central Workstation/Tester

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NOTE: A Central workstation/tester will not be required for all projects. It is functionally equivalent to the portable workstation/tester; the main difference being a larger display for the central workstation. The central workstation is primarily intended to be used in facilities in which the DDC system is monitored on a regular basis, rather than an "as needed" basis. The designer should verify the need for a central workstation with the user.

****

A central workstation/tester shall be provided and shall be able to communicate any network control panel via the primary network. The central workstation/tester shall be functionally equivalent to the portable workstation/tester but is intended to be a stationary unit. The central workstation/tester shall consist of a central computer with a nominal 14 inch VGA color display, capable of displaying up to 256 colors at a minimum resolution of 640 X 480 pixels, 32 bit microprocessor operating at a minimum of 100 MHZ. The central workstation/tester shall have, as a minimum, a 2100 MB hard drive, 32 megabytes of memory, integral pointing device, serial and parallel ports, color VGA video port for an external color monitor, 3.5 inch floppy disk drive, modem, PCMCIA type three slot, rechargeable battery, battery charger, 120 Vac power supply and network adapter (Ethernet IEEE802.3 or ARCNET). The central workstation/tester shall:

a. Run DDC diagnostics.

b. Load all DDC memory resident programs and information, including parameters and constraints.

c. Display any AI, DI, AO, DO, or PA point in engineering units for analog points or status for digital points.

d. Control any AO or DO.

e. Provide an operator interface, contingent on password level, allowing the operator to use full English language words and acronyms, or an object oriented graphical user interface.

f. Display database parameters.

g. Modify database parameters.

h. Accept DDC software and information for subsequent loading into a specific DDC. Provide all necessary software and hardware required to support this function, including an EIA ANSI/EIA/TIA-232-F port.

i. Disable/enable each DDC.

j. Perform all workstation functions as specified.

2.14.10 Data Terminal Cabinet (DTC)

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NOTE: DTC's are not to be used in all installations, because of cost considerations. Use them where a future interface is of concern and would outweigh the cost penalty associated with the DTC. If the designer determines that DTCs are necessary, they must be shown on the drawings in the required locations.
****

The DTC shall be an independent metallic enclosure not physically part of the network control panel/RIU as shown. The DTC shall be sized to accommodate the number of I/O functions required for each network control panel/RIU, including installed spares, plus 10% expansion for each type of I/O function provided. The DTC shall be divided into analog input and output groups and digital input and output groups. The DTC shall be provided with double sided screw type terminal strips. One side of the terminal strip shall be used for termination of field wiring from instrumentation-mentation and controls. The other side shall be used to connect the DTC to the network control panel/RIU. Terminal strips shall have individual terminal identification numbers. The DTC shall be a locking type mounting enclosure, with common keying and door switch wired to an input for intrusion alarm annunciation at the central station. DTC keying shall be identical to network control panel/RIU keying.

2.15 DDC SOFTWARE

All DDC software described in this specification shall be furnished as part of the complete DDC System.

2.15.1 Operating System

Each DDC shall contain an operating system that controls and schedules that DDC's activities in real time. The DDC shall maintain a point database in its memory that includes all parameters, constraints, and the latest value or status of all points connected to that DDC. The execution of DDC application programs shall utilize the data in memory resident files. The operating system shall include a real time clock function that maintains the seconds, minutes, hours, date and month, including day of the week. Each DDC real time clock shall be automatically synchronized with the network control panel real time clock at least once per day to plus or minus 10 seconds. When the network control panel is connected to a central workstation/tester, the network control panel RTC shall be updated by the central workstation/tester RTC. The time synchronization shall be accomplished without operator intervention and without requiring system shutdown. The operating system shall allow loading of software, data files data entry, and diagnostics from the central workstation/tester both locally through the central workstation/tester port and remotely through a network control panel and the manufacturers control network.

2.15.1.1 Startup

The DDC shall have startup software that causes automatic commencement of operation without human intervention, including startup of all connected

I/O functions. A DDC restart program based on detection of power failure at the DDC shall be included in the DDC software. Upon restoration of power to the DDC, the program shall restart equipment and restore loads to the state at time of power failure, or to the state as commanded by time programs or other overriding programs. The restart program shall include start time delays between successive commands to prevent demand surges or overload trips. The startup software shall initiate operation of self-test diagnostic routines. Upon failure of the DDC, if the database and application software are no longer resident or if the clock cannot be read, the DDC shall not restart and systems shall remain in the failure mode indicated until the necessary repairs are made. If the database and application programs are resident, the DDC shall resume operation after an adjustable time delay of from 0 to 600 seconds. The startup sequence for each DDC shall include a unique time delay setting for each control output when system operation is initiated.

2.15.1.2 Operating Mode

Each DDC shall control and monitor functions as specified, independent of communications with other DDC. This software shall perform all DDC functions and DDC resident application programs as specified using data obtained from I/O functions and based upon the DDC real time clock function. When communications circuits between the DDC are operable, the DDC shall obtain real time clock updates and any required global data values transmitted from other network control panels. The DDC software shall execute commands after performing constraints checks in the DDC. Status and analog values, including alarms and other data shall be transmitted from other network control panels when communications circuits are operable. If communications are not available, each DDC shall function in stand-alone mode and operational data, including the latest status and value of each point and results of calculations, normally transmitted from other network control panels shall be stored for later transmission to the network control panel. Storage for the latest 256 values shall be provided at each network control panel. Each DDC shall accept software downloaded from the network control panel. Constraints shall reside at the DDC.

2.15.1.3 Failure Mode

Upon failure for any reason, each DDC shall perform an orderly shutdown and force all DDC outputs to a predetermined (failure mode) state, consistent with the failure modes shown and the associated control device.

2.15.2 Functions

The Contractor shall provide software necessary to accomplish the following functions, as appropriate, fully implemented and operational, within each network control panel, RIU, unitary controller and universal programmable controller.

a. Scanning of inputs.

b. Control of outputs.

c. Reporting of analog changes outside a selectable differential.

d. Reporting of unauthorized digital status.

e. Reporting of alarms automatically to network control panel.

f. Reporting of I/O status to network control panel upon request.

g. Maintenance of real time, updated by the network control panel at least once a day.

h. Communication with the network control panel.

i. Execution of DDC resident application programs.

j. Averaging or filtering of AIs.

k. Constraints checks (prior to command issuance).

l. Diagnostics.

m. Portable workstation/tester operation as specified.

n. Reset of PA by operator based on time and value.

2.15.2.1 Analog Monitoring

The system shall measure and transmit analog values including calculated analog points. An analog change in value is defined as a change exceeding a preset differential value as specified. The record transmitted for each analog value shall include a readily identifiable flag which indicates the abnormal status of the value when it deviates from operator selectable upper and lower analog limits. Analog values shall be expressed in proper engineering units with sign. Engineering units conversions shall be provided for each measurement. Each engineering units conversion set shall include range, span, and conversion equation. A vocabulary of engineering unit descriptors shall be provided, using at least three alphanumeric characters to identify information in the system. The system shall support 255 different engineering units.

2.15.2.2 Logic (Virtual) Points

Logic (virtual) points shall be software points entered in the point database which are not directly associated with a physical I/O function. Logic (virtual) points shall be analog or digital points created by calculation from any combination of digital and analog points, or other data having the properties of real points, including alarms, without the associated hardware. Logic (virtual) points shall be defined or calculated and entered into the database by the Contractor. The calculated analog point shall have point identification in the same format as any other analog point. The calculated point shall be used in any program where the real value is not obtainable directly. Constants used in calculations shall be changeable on-line by the operator. Calculated point values shall be current for use by the system within 10 seconds of the time of any input changes.

2.15.2.3 State Variables

If an analog point represents more than two (up to eight) specific states, each state shall be nameable. For example, a level sensor shall be displayed at its measured engineering units plus a state variable with named states usable in programs or for display such as low alarm/low/normal/high/high alarm.

2.15.2.4 Analog Totalization

Any analog point shall be operator assignable to the totalization program. Up to eight analog values shall be totalized within a selectable time period. At the end of the period, the totals shall be stored. Totalization shall then restart from zero for the next time period. The program shall keep track of the peak and total value measured during the current period and for the previous period. The operator shall be able to set or reset each totalized value individually. The time period shall be able to be operator defined, modified or deleted on-line.

2.15.2.5 Energy Totalization

The system shall calculate the heat energy in Btus, for each energy source consumed by the mechanical systems specified, totalize the calculated Btus, the instantaneous rate in Btus per hour, and store totals in thousands of Btus (MBtu). The Btus calculated shall be totalized for an adjustable time period. The time period shall be defined uniquely for each Btu totalization.

2.15.2.6 Trending

Any analog or calculated point shall be operator assignable to the trend program. Up to eight points shall be sampled at individually assigned intervals, selectable between one minute and two hours. A minimum of the most recent 128 samples of each trended point shall be stored. The sample intervals shall be able to be defined, modified, or deleted on-line.

2.15.3 I/O Point Database/Parameter Definition

Each I/O point shall be defined in a database residing in the DDC. The definition shall include all physical parameters associated with each point. Each point shall be defined and entered into the database by the Contractor, including as applicable:

a. Name.

b. Device or sensor type (i.e., sensor, control relay, motors).

c. Point identification number.

d. Unit.

e. Building number.

f. Area.

g. Island.

h. DDC number and channel address.

i. KW (running).

j. KW (starting).

k. Sensor range.

l. Controller range.

m. Sensor span.

n. Controller span.

o. Engineering units conversion (scale factor).

p. Setpoint (analog).

q. High reasonableness value (analog).

r. Low reasonableness value (analog).

s. High alarm limit differential (return to normal).

t. Low alarm limit differential (return to normal).

u. High alarm limit (analog).

v. Low alarm limit (analog).

w. Alarm disable time period upon startup or change of setpoint.

x. Analog change differential (for reporting).

y. Alarm class and associated primary message text.

z. High accumulator limit (pulse).

aa. Status description.

bb. Run time target.

cc. Failure mode as specified and shown.

dd. Constraints as specified.

2.15.4 Alarm Processing

Each DDC shall have alarm processing software for AI, DI, and PA alarms for all real and virtual points connected to that DDC.

2.15.4.1 Digital Alarms Definition

Digital alarms are those abnormal conditions indicated by DIs as specified and shown.

2.15.4.2 Analog Alarms Definition

Analog alarms are those conditions higher or lower than a defined value, as measured by an AI. Analog readings shall be compared to predefined high and low limits, and alarmed each time a value enters or returns from a limit condition. Unique high and low limits shall be assigned to each analog point in the system. Analog alarm limits shall be stored in the DDC database. Each analog alarm limit shall have an associated unique limit differential specifying the amount by which a variable must return into the proper operating range before being annunciated as a return-to-normal-state. All limits and differentials shall be entered on-line by the operator in limits of the measured variable, without interruption or loss of monitoring of the point concerned. The program shall automatically change the high or low limits or both, of any analog point, based on time scheduled operations as specified, allowing for a time interval before the alarm limit becomes effective. In CPA applications, key the limit to a finite deviation traveling with the setpoint. The system shall automatically suppress analog alarm reporting associated with a digital point when that digital point is turned off.

2.15.4.3 Pulse Accumulator Alarms Definition

Pulse accumulator alarms are those conditions calculated from totalized values of accumulator inputs or PA input rates that are outside defined limits as specified and shown. PA totalized values shall be compared to predefined limits and alarmed each time a value enters a limit condition. Unique limits shall be assigned to each PA point in the system. Limits shall be stored in the DDC database.

2.15.5 Constraints

2.15.5.1 Equipment Constraints Definitions

Each control point in the database shall have DDC resident constraints defined and entered by the Contractor, including as applicable:

a. Maximum starts (cycles) per hour.

b. Minimum off time.

c. Minimum on time.

d. High limit (value in engineering units).

e. Low limit (value in engineering units).

2.15.5.2 Constraints Checks

Control devices connected to the system shall have the DDC memory resident constraints checked before each command is issued to insure that no equipment damage will result from improper operation. Each command shall be executed by the DDC only after all constraints checks have been passed. Each command point shall have unique constraints assigned. High and low "reasonableness" values or one differential "rate-of-change" value shall be assigned to each AI. Values outside the reasonableness limits shall be rejected and an alarm message sent to the network control panel or portable workstation/tester. Status changes and analog point values shall be reported to the workstation upon operator request, such as for reports, alphanumeric displays, graphic displays, and application programs. Each individual point shall be capable of being selectively disabled by the operator from a workstation/tester. Disabling a point shall prohibit monitoring and automatic control of that point.

2.15.6 Diagnostics

Each DDC shall have self-test diagnostic routines implemented in firmware. The tests shall include routines that exercise memory. Diagnostic software shall be usable in conjunction with the central workstation/tester and portable workstation/tester. The software shall display messages in English to inform the tester's operator of diagnosed problems.

2.15.7 Summer-Winter Operation Monitoring

The system shall provide software to automatically change the operating parameters, monitoring of alarm limits, and start-stop schedules for each mechanical system from summer to winter and vice-versa. The software shall provide automatic commands to applications programs to coordinate proper summer or winter operation. Change over setpoints shall be operator selectable and settable.

2.15.8 Control Sequences and Control Loops

Sufficient memory shall be provided to implement the requirements specified and shown for each DDC. Specific functions to be implemented are defined in individual system control sequences and database tables shown in the drawings, and shall include, as applicable, the following:

a. PI Control: This function shall provide proportional control and proportional plus integral control.

b. Two Position Control: This function shall provide control for a two state device by comparing a set point against a process variable and an established deadband.

c. Floating Point Control: This function shall exercise control when an error signal exceeds a selected deadband, and shall maintain control until the error is within the deadband limits.

d. Signal Selection: This function shall allow the selection of the highest or lowest analog value from a group of analog values as the basis of control. The function shall include the ability to cascade analog values so that large numbers of inputs can be reduced to one or two outputs.

e. Signal Averaging: This function shall allow the mathematical calculation of the average analog value from a group of analog values as the basis of control. The function shall include the ability to "weight" the individual analog values so that the function output can be biased as necessary to achieve proper control.

f. Reset Function: This function shall develop an AO based on up to two AIs and one operator specified reset schedule.

g. Cooling/Heating Operation Program: Software shall be provided to change, either automatically or on operator command, the operating parameters, monitoring of alarm limits, and start-stop schedules for each mechanical system where such a change from cooling to heating and vice versa is meaningful. The software shall provide commands to application programs to coordinate cooling or heating mode operation. Software shall automatically switch facilities from cooling to heating, and vice versa, based on schedules or temperatures. All HVAC equipment and systems shall be assigned to the program.

2.15.9 Command Priorities

A scheme of priority levels shall be provided to prevent interaction of a command of low priority with a command of higher priority. The system shall require the latest highest priority command addressed to a single point to be stored for a period of time longer than the longest time constraint in the on and off states, insuring that the correct command shall be issued when the time constraint is no longer in effect or report the rejected command. Override commands entered by the operator shall have higher priority than those emanating from applications programs.

2.15.10 Resident Application Software

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NOTE: Specify only those applications programs to be implemented at time of acceptance. Do not specify a program unless sensors and controls required to implement it are included in the design package.

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The Contractor shall provide resident applications programs to achieve the sequences of operation, parameters, constraints, and interlocks necessary to provide control of the systems connected to the DDC system. Application programs shall be resident and shall execute in the DDC, and shall coordinate with each other, to insure that no conflicts or contentions remain unresolved. The Contractor shall coordinate the application programs specified with the equipment and controls operation, and other specified requirements. A scheme of priority levels shall be provided to prevent interaction of a command of low priority with a command of higher priority. The system shall require the latest highest priority command addressed to a single point to be stored for a period of time longer than the longest time constraint in the ON and OFF states, insuring that the correct command shall be issued when the time constraint is no longer in effect or the rejected command shall be reported. Override commands entered by the operator shall have higher priority than those emanating from application programs.

2.15.10.1 Program Inputs and Outputs

The Contractor shall select the appropriate program inputs listed for each application program to calculate the required program outputs. Where the specific program inputs are not available, a "default" value or virtual point appropriate for the equipment being controlled and the proposed sequence of operation shall be provided to replace the missing input, thus allowing the application program to operate. AIs to application programs shall have an operator adjustable deadband to preclude short cycling or hunting. Program outputs shall be real analog or digital outputs or logic (virtual) points as required to provide the specified functions. The Contractor shall select the appropriate input and output signals to satisfy the requirements for control of systems as shown.

2.15.10.2 DDC General Conditions

The Contractor shall provide software required to achieve the sequences of operation, parameters, constraints, and interlocks shown. Application software shall be resident in the DDC in addition to any other required software. In the event of a DDC failure, the controlled equipment shall continue to function in the failure mode shown.

2.15.10.3 Scheduled Start/Stop Program

This program shall start and stop equipment based on a time of day schedule for each day of the week, and on a holiday schedule. To eliminate power surges, an operator adjustable time delay shall be provided between consecutive start commands.

a. Program Inputs:

(1) Day of week/holiday.

(2) Time of day.

(3) Cooling and heating high-low alarm limits.

(4) Cooling and heating start-stop schedules.

(5) Cooling or heating mode of operation.

(6) Equipment status.

(7) Equipment constraints.

(8) Consecutive start time delay.

b. Program Outputs: Start/stop signal.

2.15.10.4 Optimum Start/Stop Program

This program shall start and stop equipment as specified for the scheduled start/stop program, but shall include a sliding schedule based on indoor and outdoor air conditions. The program shall take into account the thermal characteristics of the structure, and indoor and outdoor air conditions, using prediction software to determine the minimum time of HVAC system operation needed to satisfy space environmental requirements at the start of the occupied cycle, and determine the earliest time for stopping equipment at the day's end without exceeding space environmental requirements. An adaptive control algorithm shall be utilized to automatically adjust the constants used in the program.

a. Program Inputs:

(1) Day of week/holiday.

(2) Time of day.

(3) Cooling or heating mode of operation.

(4) Equipment status.

(5) Cooling and heating building occupancy schedules.

(6) Space temperature.

(7) Building heating constant (operator adjustable and automatically optimized).

(8) Building cooling constant (operator adjustable and automatically optimized).

(9) OA temperature.

(10) Required space temperature at occupancy (heating).

(11) Required space temperature at occupancy (cooling).

(12) Equipment constraints.

(13) Cooling and heating high-low alarm limits.

b. Program Outputs: Start/stop signal.

2.15.10.5 Day-Night Setback Program

The software shall limit the rise or drop of space temperature (or specified fluid temperature) during unoccupied hours. Whenever the space temperature (or specified fluid temperature) is above (or below for heating) the operator assigned temperature limit, the system shall be turned on until the temperature is within the assigned temperature limit.

a. Program Inputs:

(1) Day of week.

(2) Time of day.

(3) Cooling or heating mode of operation.

(4) Cooling and heating occupancy schedules.

(5) Equipment status.

(6) Space temperature (or specified fluid temperature).

(7) Minimum space temperature (or specified fluid temperature) during unoccupied periods.

(8) Maximum space temperature (or specified fluid temperature) during unoccupied periods.

(9) Equipment constraints.

b. Program Outputs: Start/stop signal.

2.15.10.6 Economizer Program I

The software shall reduce the HVAC system cooling requirements when the OA dry bulb temperature is less than the return air temperature. When the OA dry bulb temperature is above the return air temperature or changeover setpoint, the OA dampers, return air dampers, and relief air dampers shall be positioned to provide minimum required OA. When the OA dry bulb temperature is below a changeover setpoint temperature, the OA dampers, return air dampers, and exhaust air dampers shall be positioned to maintain the required mixed air temperature.

a. Program Input:

(1) Changeover conditions.

(2) OA dry bulb temperature.

(3) RA dry bulb temperature.

(4) Mixed air dry bulb temperature.

(5) Equipment constraints.

b. Program Output: Damper actuator/cooling control signal.

2.15.10.7 Ventilation/Recirculation and Flush Programs

The software shall reduce the HVAC system thermal load for two modes of operation and provide for flushing of the building as follows:

a. Ventilation mode: In this mode, the system shall precool the space prior to building occupancy. When the outside air temperature is lower than the space temperature, the outside air damper and exhaust air damper shall open to their maximum positions and the return air damper shall close to its minimum position.

b. Recirculation mode: In this mode, the system shall preheat the space prior to building occupancy. When the outside air temperature is lower than the space temperature, the outside air damper and the exhaust air damper shall close to their minimum positions and the return air damper shall open to its maximum position.

c. Flush mode: The software shall use the HVAC supply system to provide 100% outside air for ventilation purpose and flush building spaces. The network control panel shall modulate the control valves to maintain the air supply temperature setpoints while the flush program is in effect. The flush mode shall be manually initiated and have the highest priority (it shall override all other programs). The outside air damper and the exhaust air damper shall be closed at other times during unoccupied periods, except for economizer operation during day/night setback periods. For systems without mechanical cooling, this program shall, in addition to the above requirements, act as an economizer. The outside, return, and exhaust air dampers shall be modulated to maintain the required mixed air temperature setpoint. When this program is released, the outside and exhaust air dampers shall return to their minimum positions, and the return air damper shall return to its maximum position.

d. Program Inputs:

(1) Day of week.

(2) Time of day.

(3) Cooling or heating mode of operation.

(4) Equipment status.

(5) Cooling and heating occupancy schedules.

(6) OA dry bulb temperature.

(7) Space temperature.

(8) Equipment constraints.

e. Program Output: Damper actuator control signal.

2.15.10.8 Hot Deck/Cold Deck Temperature Reset Program

The software shall use space, mixed air, and deck temperatures to calculate the hot deck/cold deck temperature setpoints in dual duct and multizone HVAC systems. The program shall select the zones with the greatest heating and cooling requirements; establish the HVAC minimum hot and cold deck temperature differentials required to meet the zone temperatures; modulate valves to maintain deck temperature setpoints; and modulate zone dampers to maintain space temperature setpoints, without exceeding space humidity limits (where shown).

a. Program Inputs:

(1) Space temperature setpoint.

(2) Space humidity limit (where shown).

(3) Mixing box damper position or proportional signal from primary element.

(4) Hot deck temperature.

(5) Cold deck temperature.

(6) Zone temperatures (where shown).

(7) Space RH (where shown).

(8) Minimum space temperature during occupied periods.

(9) Maximum space temperature during occupied periods.

(10) Equipment constraints.

b. Program Outputs:

(1) Hot deck valve actuator control signal.

(2) Cold deck valve actuator control signal.

(3) Zone damper or mixing box actuator control output signal.

2.15.10.9 Reheat Coil Reset Program

The software shall select the zone with the least amount of heat required. The program shall reset the cold deck discharge temperature upward until it satisfies the zone with the lowest demand, or until the zone humidity control requirements cannot be met.

a. Program Inputs:

(1) Zone RH high limit.

(2) Zone temperature (where shown).

(3) Zone RH (where shown).

(4) Cold deck temperature.

(5) Reheat coil valve positions or proportional signals from primary elements.

(6) Minimum space temperature during occupied periods.

(7) Maximum space temperature during occupied periods.

(8) Equipment constraints.

b. Program Output: Cold deck valve actuator control signal.

2.15.10.10 Heating and Ventilating Unit Program

The software shall control hot water/steam coil valve position to maintain space/supply air temperatures for heating and ventilating units. This program shall be coordinated with the ventilation-recirculation program for damper control and the scheduled or optimum start-stop program for fan control.

a. Program Inputs

(1) Space temperature.
(2) Space temperature setpoint.
(3) Supply air temperature.
(4) Supply air temperature setpoint.

b. Program Outputs

(1) Heating or steam coil valve actuator control signal.
(2) Damper actuator control signal.

2.15.10.11 Air Volume Control Program

The software shall monitor supply and return/exhaust air flow volumes and modulate fan controls to maintain required air flow volumes and/or ratio or fixed differential of supply to return air flows. This program shall be coordinated with the ventilation-recirculation program and the economizer program for damper control and with static pressure control requirements for fan control.

a. Program Inputs

(1) Supply air flow.
(2) Return/exhaust air flow.
(3) Required supply air flow - high and low limits.
(4) Required return/exhaust air flow - high and low limits.
(5) Volume offset or ratio, as appropriate.

b. Program Outputs

(1) Supply fan volume control.
(2) Return/exhaust fan volume control.

2.15.10.12 Air Distribution Unitary Controller Software

Software shall be provided for the management and control of the air distribution terminal units. Software shall allow for operator definition of multiple air distribution terminal units as functional groups which may be treated as a single entity; monitoring, alarming and reporting of terminal unit parameters on an individual or group basis; and remote setpoint adjustment on an individual or group basis.

a. Functions:

(1) Volume control in response to temperature.
(2) Volume flow limits, minimum and maximum.
(3) Occupied and unoccupied operation with associated temperature and volume limits.
(4) Temperature setpoint override.

b. Program Inputs

(1) Space temperature.
(2) Space temperature setpoint.
(3) Space temperature setpoint limits.
(4) Supply airflow volume.
(5) Supply airflow volume high and low limits.

c. Program Outputs

(1) Supply volume control signal.
(2) Auxiliary fan start/stop signal.
(3) Supplemental heat control signal.

2.15.10.13 Chiller Selection Program

Chiller program shall be used for chiller selection as well as control and monitoring of chillers. The software shall select the most efficient chiller or combination of chillers based on chiller operating data to satisfy the cooling load. Based on chiller operating data, energy input vs chilled water output, the chiller with the highest efficiency shall be selected to satisfy the cooling load calculated by prediction software. The program shall calculate equipment electrical energy input based on percent full load, current, or other inputs provided, and equipment nameplate data. The program shall prevent the chiller from going to full load for a predetermined period to allow the system to stabilize, in order to determine the actual cooling load. The program shall follow the chiller manufacturer's startup and shutdown sequence requirements. Interlocks between chilled water pumps, condenser water pumps, and chiller shall be in accordance with the chiller manufacturer's requirements.

a. Program Inputs

(1) Efficiency curves.
(2) Chiller water supply temperatures.
(3) Chiller water return temperatures.
(4) Chiller water flows.
(5) Entering condenser water temperatures.
(6) Leaving condenser water temperatures.
(7) Condenser water flows.
(8) Instantaneous KW to chillers.
(9) Instantaneous KW to chilled water pumps (if variable).
(10) Instantaneous KW to condenser water pumps (if variable).
(11) Instantaneous KW to cooling tower fans (if variable).
(12) Common chilled water supply temperatures.
(13) Common chilled water return temperatures.
(14) Total chilled water flow.
(15) Chilled water pumps status.
(16) Refrigerant pressure, suction and discharge.
(17) Equipment constraints.
(18) Steam flow.

b. Program Outputs

(1) Start/stop signals for chillers (manual or automatic to control panel).
(2) Start/stop signals for chilled water pumps (manual or automatic to control panel).
(3) Start/stop signals for condenser water pumps (manual or automatic to control panel).
(4) Start/stop signals for cooling tower fans (manual or automatic to control panel).
(5) Chilled water supply temperature setpoint control signal.
(6) Chiller efficiency.

2.15.10.14 Absorption Chiller Efficiency and Monitoring Program

Chiller program shall be used for monitoring of chillers and to calculate chiller efficiency. The program shall calculate equipment efficiency based on energy input and output and other inputs provided.

a. Program Inputs

(1) Efficiency curves.
(2) Chiller water supply temperatures.
(3) Chiller water return temperatures.
(4) Chiller water flows.
(5) Entering condenser water temperatures.
(6) Leaving condenser water temperatures.
(7) Condenser water flows.
(8) Instantaneous steam to chillers.
(9) Instantaneous KW to chilled water pumps (if variable).
(10) Instantaneous KW to condenser water pumps (if variable).
(11) Instantaneous KW to cooling tower fans (if variable).
(12) Common chilled water supply temperatures.

(13) Common chilled water return temperatures.
(14) Total chilled water flow.
(15) Chilled water pumps status.
(16) Refrigerant pressure, suction and discharge.
(17) Equipment constraints.
(18) Steam pressure.
(19) Steam flow.

b. Program Outputs

(1) Chilled water supply temperatures setpoint control signal.
(2) Chiller efficiency.

2.15.10.15 Chilled Water Temperature Reset Program

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NOTE: The chiller water temperature reset program should be carefully examined prior to specifying its use on a variable volume pumping system.
****

The software shall reset the chilled water temperature supplied by a water chiller. The program shall reset the chilled water temperature upward or downward to meet the required space temperature or humidity setpoints. The program shall monitor the positions of the chilled water control valves (percent of opening) and space temperatures.

a. Program Input:

(1) Chilled water valve position.
(2) High limit for space dry bulb temperature.
(3) Chiller supply water temperature.
(4) High chilled water operating temperature.
(5) Low chilled water operating temperature.
(6) High limit for space RH.
(7) Equipment constraints.

b. Program Output: Chilled water supply temperature setpoint control signal.

2.15.10.16 Condenser Water Temperature Reset Program

The software shall reset the condenser water temperature from a fixed temperature downward when the OA wet bulb temperature will produce lower condenser water temperature. Program shall be coordinated with the chiller control loop algorithms for chiller supply, return water temperatures and safety interlocks.

a. Program Inputs:

(1) Maximum condenser water operating temperature.
(2) Minimum condenser water operating temperature.
(3) Condenser water supply temperature.
(4) OA dry bulb temperature.
(5) OA RH.
(6) Condenser water cooling equipment thermal approach characteristics.

(7) Equipment constraints.

b. Program Output: Condenser water supply temperature setpoint control signal.

2.15.10.17 Chiller Demand Limit Program

The software shall limit maximum available chiller cooling capacity in fixed steps as shown to limit electrical demand. Each fixed step shall be considered as one point in the demand limiting program. Each chiller demand control step shall be assigned an equipment priority level.

a. Program Inputs:

(1) Chiller percent capacity.
(2) Minimum cooling capacity.
(3) Equipment priority schedules.
(4) Equipment constraints.

b. Program Output

(1) Calculated percent load point.
(2) Control signal to chiller controller/panel, new setpoint (manual or automatic as shown).

2.15.10.18 Hot Water OA Reset Program

The software shall reset the hot water temperature supplied by the boiler or converter in accordance with the OA temperature or other specified independent- dent variable. The hot water supply temperature shall be reset downward or upward from a fixed temperature proportionally, as a function of OA temperature or other specified independent variable.

a. Program Inputs

(1) Reset schedule.
(2) OA dry bulb temperature or other specified independent variable.
(3) Hot water supply temperature.
(4) Maximum hot water supply temperature.
(5) Minimum hot water supply temperature.
(6) Equipment constraints.

b. Program Output: Valve actuator control signal.

2.15.10.19 Boiler Monitoring and Control

The software shall remotely monitor and control boiler operation based on boiler operational data. The program shall monitor inputs and discontinue boiler operation if any monitored point exceeds a predetermined value or changes status incorrectly. The operator shall be able to add or delete individual program input points from the list of points that will discontinue boiler operation.

a. Program Inputs

(1) Fuel flow.

(2) Fuel pressure (natural gas).
(3) Fuel temperature (heated fuel oil).
(4) Flame status.
(5) Flue gas oxygen.
(6) Flue gas temperature.
(7) Make-up or feed water flow.
(8) Furnace draft.
(9) Flue gas carbon monoxide (for boilers over 20 million BTUs).
(10) Hot water flow.
(11) Hot water pressure.
(12) Hot water supply temperature.
(13) Hot water return temperature.
(14) Hot water BTUs.
(15) Steam flow.
(16) Steam pressure.
(17) Steam temperature.
(18) Steam BTUs.
(19) Feedwater temperature.
(20) Boiler drum level.

b. Program Outputs

(1) Boiler enable/disable control signal.
(2) Boiler enable/disable permission to boiler operator for manual control.
(3) Boiler efficiency.

2.15.10.20 Heat Recovery Boiler Efficiency and Monitoring

The software shall remotely monitor and calculate efficiency of heat recovery boiler operation. The program shall monitor inputs and alarm operator if any monitored point exceeds a predetermined value or changes status incorrectly.

a. Program Inputs

(1) Exhaust gas flow (from gas turbine generator) into boiler.
(2) Exhaust gas temperature (from gas turbine generator) into boiler.
(3) Flue gas oxygen.(stack)
(4) Flue gas temperature.(stack)
(5) Make-up flow.
(6) Furnace draft.
(7) Flue gas carbon monoxide (for boilers over 20 million BTUs).
(8) Hot water flow (hot water boilers).
(9) Hot water pressure (hot water boilers).
(10) Hot water supply temperature (hot water boilers).
(11) Hot water return temperature (hot water boilers).
(12) Hot water BTUs (hot water boilers).
(13) Steam flow (steam boilers).
(14) Steam pressure (steam boilers).
(15) Steam BTUs (steam boilers).
(16) Feedwater temperature (steam boilers).
(17) Boiler drum level (steam boilers).
(18) Steam temperature.
(19) Position of diverter valve.

b. Program Output: Heat recovery boiler efficiency

2.15.10.21   Hot Water Distribution Program

The software shall control the hot water distribution temperature to individual building zones. The zone hot water distribution temperature shall be reset downward or upward from a fixed temperature proportionally as a function of OA temperature or other specified independent variable by modulating the respective zone mixing valve. The zone pump shall be stopped when the OA temperature exceeds the specified setpoint. When parallel pumps are used, the software shall alternate pump operation and shall start the standby pump (after a time delay) upon failure of the operating pump.

a. Program Inputs

(1) Zone hot water distribution temperature.
(2) Reset schedule.
(3) OA dry bulb temperature or other specified independent variable.
(4) Maximum zone hot water distribution temperature.
(5) Zone pump status.
(6) Equipment constraints.

b. Program Outputs

(1) Zone mixing valve control.
(2) Zone pump start/stop signal(s).

2.15.10.22   Domestic Hot Water Generator Program

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NOTE: Although domestic water heating may be controlled from the DDC system, this is neither included in the sequences of operation located elsewhere in this specification, nor included in the standard HVAC control system drawings. The designer must decide whether or not to utilize this feature. If this feature is utilized, the sequences of operation and the contract drawings must reflect this requirement.

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The software shall control the domestic hot water temperature by adjusting the hot water heating control valve.

a. Program Inputs

(1) Domestic hot water temperature.
(2) Domestic hot water temperature setpoint.

b. Program Output: Hot water heating control valve actuator control signal.

2.15.10.23   Lighting Control Program

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NOTE: Although lighting may be controlled from the DDC system, this is neither included in the

sequences of operation located elsewhere in this specification, nor included in the standard HVAC system drawings. The designer must decide whether or not to utilize this feature. If this feature is utilized, the sequences of operation and the contract drawings must reflect this requirement.
****

The software shall turn lights on and off based on the time of day and the day of week, including holidays. The program shall generate additional commands at operator adjustable intervals to assure that lights are off (relay operated zoned lighting only).

a. Program Inputs

(1) Day of week-holiday.

(2) Time of day.

(3) Cooling and heating start-stop schedules.

(4) Equipment status.

(5) Times of day for additional off commands (where applicable).

b. Program Output: On/off signal.

PART 3 EXECUTION

3.1 GENERAL INSTALLATION CRITERIA

3.1.1 HVAC Control System

The HVAC control system shall be completely installed and ready for operation. Dielectric isolation shall be provided where dissimilar metals are used for connection and support. Penetrations through and mounting holes in the building exterior shall be made watertight. The HVAC control system installation shall provide clearance for control system maintenance by maintaining access space between coils, access space to mixed-air plenums, and other access space required to calibrate, remove, repair, or replace control system devices. The control system installation shall not interfere with the clearance requirements for mechanical and electrical system maintenance.

3.1.2 Software Installation

Software shall be loaded for an operational system, including databases for all points, operational parameters, and system, command, and application software. The Contractor shall provide original and backup copies of source, excluding the general purpose operating systems and utility programs furnished by computer manufacturers and the non-job-specific proprietary code furnished by the system manufacturer, and object modules for software on each type of media utilized, within 30 days of formal Government acceptance. In addition, a copy of individual floppy disks of software for each DDC panel shall be provided.

3.1.3 Device Mounting Criteria

Devices mounted in or on piping or ductwork, on building surfaces, in mechanical/electrical spaces, or in occupied space ceilings shall be installed in accordance with manufacturer's recommendations and as shown. Control devices to be installed in piping and ductwork shall be provided with required gaskets, flanges, thermal compounds, insulation, piping, fittings, and manual valves for shutoff, equalization, purging, and calibration. Strap-on temperature sensing elements shall not be used except as specified.

3.1.4   Wiring Criteria

Wiring external to control panels, including low-voltage wiring, shall be installed in metallic raceways. [Nonmetallic-sheathed cables or metallic-armored cables may be installed in areas permitted by NFPA 70] [_____] Wiring shall be installed without splices between control devices and DDC panels. Instrumentation grounding shall be installed as necessary to prevent ground loops, noise, and surges from adversely affecting operation of the system. Ground rods installed by the contractor shall be tested as specified in IEEE Std 142. Cables and conductor wires shall be tagged at both ends, with the identifier shown on the shop drawings. Electrical work shall be as specified in Section 16415A ELECTRICAL WORK, INTERIOR and as shown.

3.2   CONTROL SYSTEM INSTALLATION

3.2.1   Damper Actuators

Actuators shall not be mounted in the air stream. Multiple actuators operating a common damper shall be connected to a common drive shaft. Actuators shall be installed so that their action shall seal the damper to the extent required to maintain leakage at or below the specified rate and shall move the blades smoothly.

3.2.2   Local Gauges for Actuators

Pneumatic actuators shall have an accessible and visible receiver gauge installed in the tubing lines at the actuator as shown.

3.2.3   Room Instrument Mounting

****

NOTE: Wall mounted thermostats and similar control system components accessible to the occupants in ADA compliant facilities and spaces shall be mounted 1.2 meters (48 inches) above the floor for forward reach and 1.3 meters (54 inches) for side reach. The mounting height and location for these system components shall be noted on the drawings or the following paragraph revised accordingly.

****

Room instruments , such as wall mounted thermostats, shall be mounted 60 inches above the floor unless otherwise shown. Temperature setpoint devices shall be recess mounted.

3.2.4   Freezestats

For each 20 square feet of coil face area, or fraction thereof, a freezestat shall be provided to sense the temperature at the location shown. Manual reset freezestats shall be installed in approved, accessible locations where they can be reset easily. The freezestat sensing element shall be installed in a serpentine pattern.

3.2.5 Averaging Temperature Sensing Elements

Sensing elements shall have a total element minimum length equal to 1 linear foot per square foot of duct cross-sectional area.

3.2.6 Foundations and Housekeeping Pads

Foundations and housekeeping pads shall be provided for the HVAC control system air compressors.

3.2.7 Compressed Air Stations

The air compressor assembly shall be mounted on vibration eliminators, in accordance with ASME BPVC SEC VIII D1 for tank clearance. The air line shall be connected to the tank with a flexible pipe connector. Compressed air station specialties shall be installed with required tubing, including condensate tubing to a floor drain.

3.2.8 Duct Static Pressure Sensing Elements and Transmitters

The duct static pressure sensing element and transmitter sensing point shall be located at 75% to 100% of the distance between the first and last air terminal units.

3.2.9 Indication Devices Installed in Piping and Liquid Systems

Gauges in piping systems subject to pulsation shall have snubbers. Gauges for steam service shall have pigtail fittings with cock. Thermometers and temperature sensing elements installed in liquid systems shall be installed in thermowells.

3.2.10 Tubing

3.2.10.1 Control System Installation

****

NOTE: The designer will show electric or electronic actuators for all outdoor applications.

****

The control system shall be installed so that pneumatic lines are not exposed to outside air temperatures. All tubes and tube bundles exposed to view shall be installed neatly in lines parallel to the lines of the building. Tubing between panels and actuators in mechanical/electrical spaces shall be routed so that the lines are easily traceable.

3.2.10.2 Pneumatic Lines In Mechanical/Electrical Spaces

In mechanical/electrical spaces, pneumatic lines shall be plastic tubing or copper tubing. Horizontal and vertical runs of plastic tubes or soft copper tubes shall be installed in raceways dedicated to tubing. Dedicated raceways and tubing not installed in raceways shall be supported every 6 feet for horizontal runs and every 8 feet for vertical runs.

3.2.10.3   Pneumatic Lines External To Mechanical/Electrical Spaces

Tubing external to mechanical/electrical spaces, when run in plenum ceilings, shall be soft copper with sweat fittings. Tubing not in plenum spaces shall be soft copper with sweat fittings or shall be plastic tubing in raceways dedicated to tubing. Raceways and tubing not in raceways shall be supported every 8 feet.

3.2.10.4   Connection to Liquid and Steam Lines

****

NOTE: The designer will select tubing and fitting and fitting materials appropriate for the ductwork and piping services. Stainless steel tubing will only be used when required for the application such as in corrosive atmospheres.

****

Tubing for connection of sensing elements and transmitters to liquid and steam lines shall be [copper] [Series 300 stainless steel] with [brass compression] [stainless-steel compression] fittings.

3.2.10.5   Connection to Ductwork

Tubing for connection of sensing elements and transmitters to ductwork shall be plastic tubing.

3.2.10.6   Tubing in Concrete

Tubing in concrete shall be installed in rigid conduit. Tubing in walls containing insulation, fill, or other packing materials shall be installed in raceways dedicated to tubing.

3.2.10.7   Final Connection to Actuators

Final connections to actuators shall be plastic tubing 12 inches long and unsupported at the actuator.

3.3   CONTROL SEQUENCES OF OPERATION

****

NOTE: The sequences of operation in this guide specification correspond to the standard systems depicted in TI 810-11. If the control system design deviates from those standard systems in any way, the sequence of operation must be modified accordingly.

Delete sequences of operation for HVAC system types which are not applicable to the project.

Where the sequence is applicable, edit for a specific system, using one edition of the sequence until all such systems are identified and described for the project.

The designer shall determine whether the edited sequences will appear on the contract drawings or in the contract specifications, as required by the design review agency.
****

3.3.1 General Requirements - HVAC Systems

These requirements shall apply to all primary HVAC systems unless modified herein. The sequences describe the actions of the control system for one direction of change in the HVAC process analog variable, such as temperature, humidity or pressure. The reverse sequence shall occur when the direction of change is reversed.

3.3.1.1 Supply Fan Operating

****
NOTE: The bracketed sentences and phrases in these paragraphs will be edited according to the control system requirements for interlocked fans, smoke dampers and coil pumps. If a coil circulating pump is used, the designer will describe its operation as a special interlock in the last paragraph of the sequence. If an interlocked exhaust fan is used, the designer will describe its operation as a special interlock in the last paragraph of the sequence.
****

HVAC system outside air, return air, and relief air dampers shall function as described for specific modes of operation [unless control of the dampers is assumed by the fire and smoke control system. Smoke dampers shall open before fans are allowed to start.] [Interlocked exhaust fans shall be stopped in the unoccupied and ventilation delay modes and their dampers shall be closed. Interlocked exhaust fans shall run in the occupied mode, and their dampers shall open.] Cooling coil control valves and cooling coil circulating pumps shall function as described for the specific modes of operation [unless their control is assumed by the freeze protection system.] Heating coil valves shall be under control.

3.3.1.2 Supply Fan Not Operating

When an HVAC system is stopped, [all interlocked fans shall stop,] [the smoke dampers shall close,] the outside air and relief air dampers shall close, the return air damper shall open, all stages of direct-expansion cooling shall stop, the system shall pump down if it has a pump down cycle, humidification shall stop, and cooling coil valves for coils located indoors shall close to the coil. Cooling coil valves of units located outdoors shall open to the coil. Heating coil valves shall remain under control.

3.3.1.3 Hydronic Heating - Distribution Pump Operating

Hydronic heat-exchanger valves shall be under control.

3.3.1.4 Hydronic Heating - Distribution Pump Not Operating

Hydronic heat-exchanger valves shall close.

3.3.2   Perimeter Radiation Control Sequence

All Modes - A room thermostat, located as shown, shall operate a control valve to maintain the setpoint as shown.

3.3.3   Unit Heater and Cabinet Unit Heater

All Modes - A wall-mounted thermostat with an "AUTO-OFF" switch located as shown, shall cycle the fan to maintain its setpoint as shown when the switch is in the "AUTO" position. When the switch is in the "OFF" position, the fan shall be stopped.

3.3.4   Gas-Fired Infrared Heater

A microprocessor-based room thermostat with "AUTO-OFF" switch, located as shown, shall control the infrared heater. Auto Mode - When the switch is in the "AUTO" position, the thermostat shall cycle the infrared heater to maintain the day and night setpoints. Programmed occupied times shall be considered "day" and programmed unoccupied times shall be considered "night." Off Mode - When the switch is in the "OFF" position, the infrared heater shall be off.

3.3.5   All-Air Small Package Unitary System

A microprocessor-based room thermostat, located as shown, with "HEAT-OFF-COOL" and "AUTO-ON" switches shall control the system. Heating Mode - Cooling unit shall be off, and heating shall be active. The thermostat shall operate the condensing unit and system fan to maintain the day and night setpoints as shown. Programmed occupied times shall be considered "day" and programmed unoccupied times shall be considered "night." Cooling Mode - Heating unit shall be off. During the day the thermostat shall operate the condensing units and system fan to maintain the setpoint. The condensing unit shall be off at night. Off Mode - The system shall be off. On Mode - The system fan shall run continuously. Auto Mode - The system fan shall operate whenever heating or cooling is required.

3.3.6   Dual Temperature Fan-Coil Unit

****

NOTE: Revise this paragraph accordingly when 2-way valves are used in lieu of 3-way valves.

****

All Modes - A wall-mounted thermostat, located as shown, shall cycle the fan to maintain the setpoint as shown. When the fan is on, a 3-way valve shall open to the coil. When the fan is off, the 3-way valve shall bypass the coil. An aquastat shall switch the wall-mounted thermostat action from heating mode to cooling mode whenever the hydronic dual-temperature medium is below the setpoint.

3.3.7   Central Plant Hydronic Heating with Steam/Hot Water Converter

3.3.7.1   All Modes

The DDC system shall accept a signal from a sunshielded outside air temperature sensing element and transmitter located as shown. The DDC system shall start and stop pump [_____] at the outside air temperatures shown. The DDC system shall reset the hydronic heating supply temperature setpoint in a linear schedule based on the outside air temperature as shown. The DDC system shall accept a signal from a temperature sensing element and transmitter located in the hydronic heating supply line and the DDC system output shall modulate the converter steam control valve to maintain the reset schedule setpoint in the hydronic heating supply line.

3.3.7.2 Occupied Mode

When the system time schedule places the system in the occupied mode, a space temperature sensing element and transmitter located as shown shall signal the DDC system, which shall maintain the space temperature setpoint by modulating the secondary hydronic system zone valve.

3.3.7.3 Unoccupied Mode

When the system is in the unoccupied mode, the space temperature setpoint shall be as shown.

3.3.8 Single Building Hydronic Heating with Hot Water Boiler

****

NOTE: Designers should be cautious when selecting the lower limit of hot water reset schedule. Selecting a limit too low could result in a return water temperature low enough to cause thermal shock or combustion chamber condensation in the boiler. The use of a constant volume boiler loop as depicted in TI 810-11 essentially eliminates these concerns.

****

3.3.8.1 All Modes

The DDC system shall accept a signal from a sunshielded outside air temperature sensing element and transmitter located as shown. The DDC system shall start and stop distribution pump [_____][, boiler pump [_____],] and boiler [_____] at the outside air temperatures shown. The DDC system shall reset the hydronic heating supply temperature setpoint in a linear schedule based on the outside air temperature as shown. The DDC system shall accept a signal from a temperature sensing element and transmitter located in the hydronic heating supply line and the DDC system output shall modulate the hydronic heating system control valve to maintain the reset schedule setpoint in the hydronic heating supply line.

3.3.8.2 Occupied Mode

When the system time schedule places the system in the occupied mode, a space temperature sensing element and transmitter located as shown shall signal the DDC system, which shall maintain the space temperature setpoint shown by modulating the secondary hydronic system zone valve.

3.3.8.3 Unoccupied Mode

When the system is in the unoccupied mode, the space temperature setpoint shall be as shown.

3.3.9 Central Plant High-Temperature Hot-Water Hydronic Heating

3.3.9.1 All Modes

The DDC system shall accept a signal from a sunshielded outside air temperature sensing element and transmitter located as shown. The DDC system shall start and stop pump [_____] at the outside air temperatures shown. The DDC system shall reset the hydronic heating supply temperature setpoint in a linear schedule based on the outside air temperature as shown. The DDC system shall accept a signal from a temperature sensing element and transmitter located in the hydronic heating supply line and the DDC system output shall modulate the converter high temperature hot water control valve to maintain the reset schedule setpoint in the hydronic heating supply line.

3.3.9.2 Occupied Mode

When the system time schedule places the system in the occupied mode, a space temperature sensing element and transmitter located as shown shall signal the DDC system, which shall maintain the space temperature setpoint as shown by modulating the secondary hydronic system zone valve.

3.3.9.3 Unoccupied Mode

When the system is in the unoccupied mode, the space temperature setpoint shall be as shown.

3.3.10 Central Plant Dual-Temperature Hydronic

Heating and Cooling Modes shall be manually selected.

3.3.10.1 Heating Mode

When the heating mode is selected, the system changeover valves shall close to the central plant chilled water flow and shall open to flow through the converter, and pump [_____] shall be under control of the DDC system. The DDC system shall accept a signal from a sunshielded outside air temperature sensing element and transmitter located as shown. The DDC system shall start and stop pump [_____] at the outside air temperatures shown. The DDC system shall reset the hydronic heating supply temperature setpoint in a linear schedule based on the outside air temperature. The DDC system shall accept a signal from a temperature sensing element and transmitter located in the hydronic heating supply line and the DDC system output shall modulate the converter's steam control valve to maintain the reset schedule setpoint in the hydronic heating supply line.

3.3.10.2 Cooling Mode

When the cooling mode is selected, the converter steam valve shall be closed. The DDC system shall accept a signal from a temperature sensing element and transmitter located in the system return. The DDC system shall continue to operate pump [_____] to circulate water through the system. When the system return water temperature drops below the setpoint shown, the DDC system shall allow the changeover valves to close to flow through the converter and to open to the central plant chilled water flow, and place the control of pump [_____] under control of the system time schedule. During the occupied mode, pump [_____] shall operate continuously. In the unoccupied mode, pump [_____] shall stop.

3.3.11 Central Plant High-Temperature Hot Water Dual-Temperature Hydronic

Heating and cooling modes shall be manually selected.

3.3.11.1 Heating Mode

When the heating mode is selected, the system changeover valves shall close to the central plant chilled water flow and shall open to flow through the converter, and pump [_____] shall be under control of the DDC system. The DDC system shall accept a signal from a sunshielded outside air temperature sensing element and transmitter located as shown. The DDC system shall start and stop pump [_____] at the outside air temperatures shown. The DDC system shall reset the hydronic heating supply temperature setpoint in a linear schedule based on the outside air temperature as shown. The DDC system shall accept a signal from a temperature sensing element and transmitter located in the hydronic heating supply line and the DDC system output shall modulate the converter's high-temperature hot-water control valve to maintain the reset schedule setpoint in the hydronic heating supply line.

3.3.11.2 Cooling Mode

When the cooling mode is selected, the converter high-temperature hot-water control valve shall be closed. The DDC system shall accept a signal from a temperature sensing element and transmitter located in the system return as shown. The DDC system shall continue to operate pump [_____] to circulate water through the system. When the system return water temperature drops below the setpoint shown, the DDC system shall allow the changeover valves to close to flow through the converter and to open to the central plant chilled water flow, and place the control of pump [_____] under control of the system time schedule. During the occupied mode, pump [_____] shall operate continuously. In the unoccupied mode, pump [_____] shall stop.

3.3.12 Single Building Dual-Temperature Hydronic

****

NOTE: Designers should be cautious when selecting the lower limit of hot water reset schedule. Selecting a limit too low could result in a return water temperature low enough to cause thermal shock or combustion chamber condensation in the boiler. In addition, because setpoint reset of system supply water temperature is achieved by bypassing water around the boiler, damage can occur to constant flow boilers. The use of a constant volume boiler loop as depicted in TI 810-11 essentially eliminates these concerns.

Delete references to boiler pumps in the subparagraphs below when not applicable for the project.

****

Heating and cooling modes shall be manually selected.

3.3.12.1 Heating Mode

When the heating mode is selected, chiller [_____] shall be stopped. Distribution pump [_____] shall continue to operate until the expiration of a time delay as recommended by the chiller manufacturer. At the expiration of the time delay, the system changeover valves shall close to flow through the chiller and shall open to flow through the boiler, and distribution pump [_____] shall be under control of the DDC system. The DDC system shall accept a signal from a sunshielded outside air temperature sensing element and transmitter located as shown. The DDC system shall start and stop the distribution pump [_____][, the boiler pump [_____]], and the boiler [_____] at the outside air temperatures shown. The DDC system shall reset the hydronic heating supply temperature setpoint in a linear schedule based on the outside air temperature as shown. The DDC system shall accept a signal from a temperature sensing element and transmitter located in the hydronic supply line and the DDC system output shall modulate the hydronic heating system control valve to maintain the reset schedule setpoint in the hydronic heating supply line.

3.3.12.2 Cooling Mode

When the cooling mode is selected, the boiler [_____] [and the boiler pump [_____]] shall be stopped. The DDC system shall accept a signal from a temperature sensing element and transmitter located in the system supply as shown. The DDC system shall continue to operate the distribution pump [_____] to circulate water through the system with the boiler shut off. When the system supply water temperature drops below the setpoint shown, the DDC system shall allow the changeover valves to close to flow through the boiler and to open to flow through the chiller, and shall place the chiller and the distribution pump [_____] under control of the system time schedule. During the occupied mode, the distribution pump [_____] shall operate continuously and chiller [_____] shall be permitted to operate. When the control system is in the unoccupied mode, chiller [_____] shall shut down. Distribution pump [_____] shall continue to operate until the expiration of the time delay.

3.3.13 Heating and Ventilating Unit

****

NOTE: A special interlock control sequence for each fan system will be developed by the designer if required.

****

3.3.13.1 Occupied, Unoccupied, and Ventilation Delay Operating Modes

Ventilation delay mode timing shall start prior to the occupied mode timing. The DDC system shall prevent the outside air damper from opening. At the time shown, the DDC system shall place the system in the occupied mode. At the expiration of the ventilation delay mode timing period, the DDC system shall allow the outside air damper to open. At the time shown, the DDC system shall place the control system in the unoccupied mode of operation.

3.3.13.2 Outside Air, Return Air, and Relief Air Dampers

a. Occupied Mode - The outside air, return air, and relief air dampers shall be under space temperature and economizer control.

b. Unoccupied and Ventilation Delay Modes - The dampers shall return to their normal positions.

3.3.13.3 Supply Fan Control

a. Occupied and Ventilation Delay Modes - Supply fan [_____] shall start, and shall operate continuously.

b. Unoccupied Mode - The supply fan shall cycle according to the night setback schedule. The fan shall start and stop at the setpoints as shown.

3.3.13.4 Filter

The DDC panel shall monitor the differential pressure switch across the filter and shall provide an alarm when the pressure drop exceeds the setpoint.

3.3.13.5 Freeze Protection

All Modes - A freezestat, located as shown, shall stop the supply fan, cause the outside air, return air, and relief air dampers to return to their normal position, and shall initiate a low temperature alarm if the temperature drops below the freezestat's setpoint. Return to the normal mode of operation shall require manual reset at the freezestat. The DDC system shall monitor the freezestat through auxiliary contacts and shall indicate an alarm condition when the freezestat trips.

3.3.13.6 Space Temperature Control

A space temperature sensing element and transmitter operating through the DDC system shall first gradually shut off the heating coil valve. After the heating coil valve is fully closed, the DDC system shall then gradually operate the outside air damper to admit outside air beyond the minimum quantity to maintain the setpoint as shown.

3.3.13.7 Emergency Fan Shutdown

****

NOTE: Smoke control is not addressed in this guide specification. Smoke control sequence of operation for each fan system, if beyond the requirements described, will be developed by the designer, based on the requirements and parameters of the project. The designer will account for operation of dampers and fans for pressurization and manual override of interlocks to the fire alarm system. All automatic overrides of normal HVAC control sequences will be activated through the fire protection and smoke control interface panel that the designer will design for the project.

****

All Modes - Smoke Detectors in the supply air and return air ductwork shall stop the supply fan and initiate a smoke alarm if smoke is detected at either location. Restarting the supply fan shall require manual reset at the smoke detector.

3.3.14 Multizone with Return Fan

****

NOTE: In a two-deck multizone system, given that there is no deadband between heating and cooling, reliable operation of the economizer cycle may be difficult to achieve. An economizer cycle should only be used in this system if the unit is either served by a dual-temp hydronic system, or HW and CHW availability is scheduled (i.e.- only HW is available during the heating season and vice versa). If HW and CHW are both available year-round, then an economizer cycle should not be used. The following sequence of operation should be edited accordingly. (See TI 810-11 for further details on this subject.)

****

3.3.14.1 Occupied, Unoccupied, and Ventilation Delay Modes of Operation

Ventilation delay mode timing shall start prior to the occupied mode timing. The DDC system shall prevent the outside air damper from opening. At the time shown, the DDC system shall place the system in the occupied mode. At the expiration of the ventilation delay mode timing period, the DDC system shall allow the outside air damper to open. At the time shown, the DDC system shall place the control system in the unoccupied mode of operation.

3.3.14.2 Outside Air, Return Air, and Relief Air Dampers

a. Occupied Mode - The outside air, return air, and relief air dampers shall [be under mixed air temperature and economizer control.] [open to their minimum position.]

b. Unoccupied Mode - The dampers shall return to their normal positions as shown.

c. Ventilation Delay Mode - The dampers shall return to their normal positions as shown, [except when under economizer control] [_____].

3.3.14.3 Supply Fan and Return Fan Control

a. Occupied and Ventilation Delay Modes - Supply fan [_____] and return fan [_____] shall start, and shall operate continuously.

b. Unoccupied Mode - The supply fan and the return fan shall cycle according to the night setback schedule. The fans shall start and stop at the setpoints.

3.3.14.4 Filter

A differential pressure switch across the filter shall initiate a filter alarm when the pressure drop across the filter reaches the setpoint as shown.

3.3.14.5 Hot-Deck Heating Coil

****
NOTE: Reset of the hot-deck discharge temperature setpoint should not be used in conjunction with outside air reset of the heating water supply temperature. If the heating water supply temperature setpoint is being reset based on outside air temperature, delete the related portions of this paragraph.
****

All Modes - The DDC system shall modulate the control valve from the signal of a temperature sensing element and transmitter located in the discharge air of the coil to maintain the setpoint. A temperature sensing element and transmitter in the outside air intake shall reset the hot-deck temperature setpoint with respect to the outside air temperature signal in a linear schedule as shown.

3.3.14.6 Freeze Protection

All Modes - A freezestat, located as shown, shall stop the supply and return fans, cause the outside air, return air, and relief air dampers to return to their normal position, and shall initiate a low temperature alarm if the temperature drops below the freezestat's setpoint. Return to the normal mode of operation shall require manual reset at the freezestat. The DDC system shall monitor the freezestat through auxiliary contacts and shall indicate an alarm condition when the freezestat trips.

3.3.14.7 Cold-Deck Coil

a. Occupied and Ventilation Delay Modes - The control valve shall be modulated by the DDC system from the signal of a temperature sensing element and transmitter located in the coil discharge air to maintain the setpoint as shown.

b. Unoccupied Mode - The DDC system shall close the cooling coil control valve.

3.3.14.8 Economizer Control

****
NOTE: When an economizer cycle is not to be used, delete this paragraph.
****

The DDC system shall accept the signal of an outside air temperature sensing element and transmitter and the signal of a return air temperature sensing element and transmitter. The DDC system shall perform switch over between outside air economizer control mode and minimum outside air mode. Until the outside air temperature rises above the setpoint, the DDC system shall hold the system in the minimum outside air mode. When the outside air temperature rises above the setpoint, the DDC system shall place the AHU in the economizer mode or in the minimum outside air mode as determined by a comparison of the outside air and return air temperatures in accordance with the differential temperature setpoints as shown. When the outside air temperature is low with respect to the return air temperature, the AHU shall be in the economizer mode. When the DDC system places the control system in the minimum outside air mode, the outside air damper shall be open to the minimum outdoor air setting.

3.3.14.9   Mixed Air Temperature Control

****

NOTE: When an economizer cycle is not to be used, delete this paragraph.

****

When the DDC system places the system in the economizer mode, it shall modulate the dampers from the signal of a temperature sensing element and transmitter in the mixed air stream to maintain the setpoint as shown.

3.3.14.10   Zone Damper Control

All Modes - A space temperature sensor for each zone shall signal the DDC system to gradually operate the zone mixing damper to heat and cool its respective zone by mixing cold-deck air and hot-deck air to maintain the setpoint. On a rise in space temperature, the hot-deck damper shall gradually close, and the cold-deck damper shall gradually open.

3.3.14.11   Emergency Fan Shutdown

****

NOTE: Smoke control is not addressed in this guide specification. Smoke control sequence of operation for each fan system, if beyond the requirements described, will be developed by the designer, based on the requirements and parameters of the project. The designer will account for operation of dampers and fans for pressurization and manual override of interlocks to the fire alarm system. All automatic overrides of normal HVAC control sequences will be activated through the fire protection and smoke control interface panel that the designer will design for the project.

****

All Modes - Smoke detectors in the supply air and return air ductwork shall stop the supply fan and the return fan and initiate a smoke alarm if smoke is detected at either location. Restarting the supply fan and the return fan shall require manual reset at the smoke detectors.

3.3.15   Dual-Duct Multizone with Return Fan

****

NOTE: In a dual-duct multizone system, given that there is no deadband between heating and cooling, reliable operation of the economizer cycle may be difficult to achieve. An economizer cycle should only be used in this system if the unit is either served by a dual-temp hydronic system, or HW and CHW availability is scheduled (i.e.- only HW is available during the heating season and vice versa). If HW and CHW are both available year-round, then an economizer cycle should not be used. The following sequence of operation should be edited accordingly. (See TI 810-11 for further details on this subject.)

****

3.3.15.1 Occupied, Unoccupied, and Ventilation Delay Modes of Operation

Ventilation delay mode timing shall start prior to the occupied mode timing. The DDC system shall prevent the outside air damper from opening. At the time shown, the DDC system shall place the system in the occupied mode. At the expiration of the ventilation delay mode timing period, the DDC system shall allow the outside air damper to open. At the time shown, the DDC system shall place the control system in the unoccupied mode of operation.

3.3.15.2 Outside Air, Return Air, and Relief Air Dampers

a. Occupied Mode - The outside air, return air, and relief air dampers shall [be under mixed air temperature and economizer control.] [open to their minimum position.]

b. Unoccupied Mode - The dampers shall return to their normal positions as shown.

c. Ventilation Delay Mode - The dampers shall return to their normal positions as shown, [except when under economizer control] [_____].

3.3.15.3 Supply Fan and Return Fan Control

a. Occupied and Ventilation Delay Modes - Supply fan [_____] and return fan [_____] shall start, and shall operate continuously.

b. Unoccupied Mode - The supply fan and the return fan shall cycle according to the night setback schedule. The fans shall start and stop at the setpoints as shown.

3.3.15.4 Filter

A differential pressure switch across the filter shall initiate the filter alarm when the pressure drop across the filter reaches the setpoint as shown.

3.3.15.5 Hot-Deck Heating Coil

****
NOTE: Reset of the hot-deck discharge temperature setpoint should not be used in conjunction with outside-air reset of the heating water supply temperature. If the heating water supply temperature setpoint is being reset based on outside air temperature, delete the relevant portions of this paragraph.
****

All Modes - The DDC system shall modulate the control valve from the signal of a temperature sensing element and transmitter located in the discharge air of the coil to maintain the setpoint. A temperature sensing element and transmitter in the outside air intake shall reset the hot-deck temperature setpoint with respect to the outside air temperature signal in a linear schedule as shown.

3.3.15.6 Freeze Protection

All Modes - A freezestat, located as shown, shall stop the supply and return fans, cause the outside air, return air, and relief air dampers to return to their normal position, and shall initiate a low temperature alarm if the temperature drops below the freezestat's setpoint as shown. Return to the normal mode of operation shall require manual reset at the freezestat. The DDC system shall monitor the freezestat through auxiliary contacts and shall indicate an alarm condition when the freezestat trips.

3.3.15.7 Cold-Deck Cooling Coil

a. Occupied and Ventilation Delay Modes - The control valve shall be modulated by the DDC system from the signal of a temperature sensing element and transmitter in the coil discharge air to maintain the setpoint as shown.

b. Unoccupied Mode - The cooling coil control valve shall be closed.

3.3.15.8 Economizer Control

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NOTE: When an economizer cycle is not to be used, delete this paragraph.

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The DDC system shall accept the signal of an outside air temperature sensing element and transmitter and the signal of a return air temperature sensing element and transmitter. The DDC system shall perform switchover between outside air economizer control mode and minimum outside air mode. Until the outside air temperature rises above the setpoint, the DDC system shall hold the system in the minimum outside air mode. When the outside air temperature rises above the setpoint, the DDC system shall place the AHU in the economizer mode or in the minimum outside air mode, as determined by a comparison of the outside air and return air temperatures in accordance with the differential temperature setpoints. When the outside air temperature is low with respect to the return air temperature, the AHU shall be in the economizer mode. When the DDC system places the control system in the minimum outside air mode, the outside air damper shall be open to the minimum outdoor air setting.

3.3.15.9 Mixed Air Temperature Control

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NOTE: When an economizer cycle is not to be used, delete this paragraph.

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When the DDC system places the AHU in the economizer mode, it shall modulate the dampers from the signal of a temperature sensing element and transmitter in the mixed air stream to maintain the setpoint as shown.

3.3.15.10 Dual-Duct Terminal Box

All Modes - A space temperature sensor for each zone shall signal the DDC system to gradually operate the control dampers of the dual-duct box to heat and cool its respective zone by mixing cold-duct air and hot-duct air to maintain the setpoint as shown. On a rise in space temperature, the hot-duct damper shall gradually close, and the cold-duct damper shall gradually open.

3.3.15.11 Emergency Fan Shutdown

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NOTE: Smoke control is not addressed in this guide specification. Smoke control sequence of operation for each fan system, if beyond the requirements described, will be developed by the designer, based on the requirements and parameters of the project. The designer will account for operation of dampers and fans for pressurization and manual override of interlocks to the fire alarm system. All automatic overrides of normal HVAC control sequences will be activated through the fire protection and smoke control interface panel that the designer will design for the project.

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All Modes - Smoke detectors in the supply air and return air ductwork shall stop the supply fan and the return fan and initiate a smoke alarm if smoke is detected at either location. Restarting the supply fan and the return fan shall require manual reset at the smoke detectors.

3.3.16 Bypass Multizone with Return Fan

3.3.16.1 Occupied, Unoccupied, and Ventilation Delay Modes of Operation

Ventilation delay mode timing shall start prior to the occupied-mode timing. The DDC system shall prevent the outside air damper from opening. At the time shown, the DDC system shall place the system in the occupied mode. At the expiration of the ventilation delay mode timing period, the DDC system shall allow the outside air damper to open. At the time shown, the DDC system shall place the control system in the unoccupied mode of operation.

3.3.16.2 Outside Air, Return Air, and Relief air Dampers

a. Occupied Mode - The outside air, return air, and relief air dampers shall be under mixed air temperature and economizer control.

b. Unoccupied Mode - The dampers shall return to their normal positions as shown.

c. Ventilation Delay Mode - The dampers shall return to their normal positions as shown, except when under economizer control.

3.3.16.3 Supply Fan and Return Fan Control

a. Occupied and Ventilation Delay Modes - Supply fan [_____] and return fan [_____] shall start, and shall operate continuously.

b. Unoccupied Mode - The supply fan and the return fan shall cycle according to the night setback schedule. The fans shall start and stop at the setpoints as shown.

3.3.16.4 Filter

A differential pressure switch across the filter shall initiate a filter alarm when the pressure drop across the filter reaches the setpoint as shown.

3.3.16.5 Freeze Protection

All Modes - A freezestat, located as shown, shall stop the supply and return fans, cause the outside air, return air, and relief air dampers to return to their normal position, and shall initiate a low temperature alarm if the temperature drops below the freezestat's setpoint. Return to the normal mode of operation shall require manual reset at the freezestat. The DDC system shall monitor the freezestat through auxiliary contacts and shall indicate an alarm condition when the freezestat trips.

3.3.16.6 Cold Deck Coil

a. Occupied and Ventilation Delay Modes - The control valve shall be modulated by the DDC system from the signal of a temperature sensing element and transmitter located in the coil discharge air to maintain the setpoint as shown.

b. Unoccupied Mode - The DDC system shall close the cooling coil control valve.

3.3.16.7 Economizer Control

The DDC system shall accept the signal of an outside air temperature sensing element and transmitter and the signal of a return air temperature sensing element and transmitter. The DDC system shall perform switchover between outside air economizer control mode and minimum outside air mode. Until the return air temperature rises above the setpoint, the DDC system shall hold the system in the minimum outside air mode. When the return air temperature rises above the setpoint, the DDC system shall place the AHU in the economizer mode or in the minimum outside air mode, as determined by a comparison of the outside air and return air temperatures in accordance with the differential temperature setpoints. When the outside air temperature is low with respect to the return air temperature, the AHU shall be in the economizer mode. When the DDC system places the control system in the minimum outside air mode, the outside air damper shall be open to the minimum outdoor air setting.

3.3.16.8 Mixed Air Temperature Control

When the DDC system places the system in the economizer mode, it shall modulate the dampers from the signal of a temperature sensing element and transmitter in the mixed air stream to maintain the setpoint as shown.

3.3.16.9 Zone Control

All Modes - A space temperature sensor for each zone shall signal the DDC system to gradually operate the zone mixing damper and heating coil to heat and cool its respective zone by mixing cold-deck air and bypass-deck air to maintain the setpoint as shown. On a rise in space temperature the heating coil valve shall gradually close and after a deadband as shown, the bypass damper shall gradually close, and the cold deck damper shall gradually open.

3.3.16.10 Emergency Fan Shutdown

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NOTE: Smoke control is not addressed in this guide specification. Smoke control sequence of operation for each fan system, if beyond the requirements described, will be developed by the designer, based on the requirements and parameters of the project. The designer will account for operation of dampers and fans for pressurization and manual override of interlocks to the fire alarm system. All automatic overrides of normal HVAC control sequences will be activated through the fire protection and smoke control interface panel that the designer will design for the project.

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All Modes - Smoke detectors in the supply air and return air ductwork shall stop the supply fan and the return fan and initiate a smoke alarm if smoke is detected at either location. Restarting the supply fan and the return fan shall require manual reset at the smoke detectors.

3.3.17 Variable Air Volume Control Sequence without Return Fan

3.3.17.1 Occupied, Unoccupied, and Ventilation Delay Modes of Operation

Ventilation delay mode timing shall start prior to the occupied mode timing. During ventilation delay mode, the dampers shall remain in their normal positions as shown, except when under economizer control. At the time shown, the DDC system shall place the system in the occupied mode. At the expiration of the ventilation delay mode timing period, the DDC system shall place the minimum outside air damper under minimum outside air flow control and shall place the economizer outside air, return air, and relief air dampers under economizer control and mixed air temperature. At the time shown, the DDC system shall place the control system in the unoccupied mode of operation and all dampers shall return to their normal positions as shown.

3.3.17.2 Supply Fan Control

a. Occupied and Ventilation Delay Modes - Supply fan [_____] shall start, and operate continuously.

b. Unoccupied Mode - The supply fan shall cycle according to the night setback schedule. The fan shall start and stop at the setpoints as shown.

3.3.17.3 Supply Duct Pressurization Control

When the supply fan starts, the DDC system shall modulate the inlet vanes from the signal of a static pressure sensing element and transmitter to maintain the setpoint as shown. A high limit static pressure switch in the fan discharge shall stop the supply fan and initiate a high static alarm when the static pressure exceeds the setpoint. When the fan is off, the inlet vanes shall be closed.

3.3.17.4 Filters

A differential pressure switch across each filter shall initiate a filter alarm when the pressure drop across the filter reaches the setpoint as shown.

3.3.17.5 Freeze Protection

All Modes - A freezestat, located as shown, shall stop the supply fan, cause the outside air, return air, and relief air dampers to return to their normal position, and shall initiate a low temperature alarm if the temperature drops below the freezestat's setpoint as shown. The DDC system shall monitor the freezestat through auxiliary contacts and shall indicate an alarm condition when the freezestat trips.

3.3.17.6 Cooling Coil

a. Occupied and Ventilation Delay Modes - The cooling coil control valve shall be modulated by the DDC system from the signal of a temperature sensing element and transmitter located in the coil discharge air to maintain the setpoint as shown.

b. Unoccupied Mode - The cooling coil control valve shall remain closed.

3.3.17.7 Minimum Outside Air Flow Control

a. Occupied Mode - The minimum outside air damper shall be modulated to maintain the minimum outside air flow at setpoint, as sensed by an air flow measurement station located in the minimum outside air duct.

b. Unoccupied and Ventilation Delay Modes - The minimum outside air damper shall remain closed.

3.3.17.8 Economizer and Mixed Air Temperature Control

The DDC system shall accept the signal of an outside air temperature sensing element and transmitter and the signal of a return air temperature sensing element and transmitter. When the return air temperature is above the economizer setpoint, and the outside air temperature is sufficiently below the return air temperature to be effective for cooling, the DDC system shall place the AHU in the economizer mode by modulating the economizer outside air, relief air, and the return air dampers to maintain the mixed air temperature at setpoint. As the economizer outside air and relief air dampers open, the return air damper closes. When the system is not in economizer mode, the economizer outside air and relief air dampers shall remain closed and the return air damper shall remain open.

3.3.17.9 Pressure Independent Terminal VAV Box with Velocity Controller

All Modes - The control damper of the VAV box shall modulate in response to the signal from a flow sensing element at the discharge or inlet of the VAV box to a microprocessor based VAV box velocity controller. The velocity controller shall control the box damper from the minimum flow position to the full flow position from the signal of a space temperature sensing element located as shown. When the space temperature decreases, the damper shall gradually close to the minimum flow position to maintain the cooling setpoint as shown. When the space temperature calls for heating after the minimum flow position is reached, control shall then pass through a temperature dead band as shown. When the space temperature has dropped through the dead band, the duct heater coil shall be gradually controlled to maintain the heating setpoint as shown.

3.3.17.10 Fan Powered Terminal VAV Box

a. Series Fan Powered Terminal Box. All Modes - The VAV box fan shall be energized from an upstream duct pressure switch confirming HVAC system fan operation. A space temperature sensing element, located as shown, acting through a microprocessor based VAV box controller, shall modulate the supply air control damper, mixing the supply air and recirculating room air to provide a constant volume of air to the space to maintain the cooling set point as shown until the supply air damper closes to minimum supply air flow. When the space temperature calls for heat after the supply air damper is closed to minimum flow and the VAV box is in maximum recirculation, control shall then pass through the temperature dead band. When the space temperature has dropped through the temperature dead band, the duct heater coil shall be gradually controlled to maintain the heating setpoint.

b. Parallel Fan Powered Terminal VAV Box. All Modes - A space temperature sensing element, located as shown, acting through a microprocessor based VAV box controller, shall modulate the supply air control damper to maintain the cooling setpoint as shown until the supply air damper closes to minimum supply air flow. When the space temperature calls for heat after the supply air damper is closed to minimum flow, control shall then pass through the temperature deadband, and the VAV box fan shall be energized. When the space temperature has dropped through a second temperature deadband, the duct heater coil shall be gradually controlled to maintain the heating setpoint.

3.3.17.11 Emergency Fan Shutdown

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NOTE: Smoke control is not addressed in this guide specification. Smoke control sequence of operation for each fan system, if beyond the requirements described, will be developed by the designer, based on the requirements and parameters of the project. The designer will account for operation of dampers and fans for pressurization and manual override of interlocks to the fire alarm system. All automatic overrides of normal HVAC control sequences will be activated through the fire protection and smoke control interface panel that the designer will design for the project.

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All Modes - Smoke detectors in the supply air and return air ductwork shall stop the supply fan and initiate a smoke alarm if smoke is detected at either location. Restarting the supply fan shall require manual reset at the smoke detector.

3.3.18 Variable Air Volume Control Sequence with Return Fan

3.3.18.1 Occupied, Unoccupied, and Ventilation Delay Modes of Operation

Ventilation delay mode timing shall start prior to the occupied mode timing. During ventilation delay mode, the dampers shall remain in their normal positions as shown, except when under economizer control. At the time shown, the DDC system shall place the system in the occupied mode. At the expiration of the ventilation delay mode timing period, the DDC system shall place the minimum outside air damper under minimum outside air flow control and shall place the economizer outside air, return air, and relief air dampers under economizer and mixed air temperature control. At the time shown, the DDC system shall place the control system in the unoccupied mode of operation and dampers shall return to their normal positions as shown.

3.3.18.2 Fan Control

a. Occupied and Ventilation Delay Modes - Supply fan and return fan shall operate continuously.

b. Unoccupied Mode - The supply fan and the return fan shall cycle according to the night setback schedule. The fans shall start and stop at the setpoints as shown.

3.3.18.3 Supply Duct Pressurization Control

When the supply fan starts, the DDC system shall modulate the inlet vanes from the signal of a static pressure sensing element and transmitter to maintain the setpoint as shown. A high limit static pressure switch in the fan discharge shall stop the supply fan and the return fan and initiate a high static alarm when the static pressure exceeds the setpoint. When the fans are off, the inlet vanes shall be closed.

3.3.18.4 Return Fan Volume Control

When the return fan starts, the DDC system shall modulate the return fan inlet vanes from the signals of an air flow measurement station and transmitter in the return air ductwork, in combination with an air flow measurement station and transmitter in the supply air ductwork, to maintain a constant difference between supply air and return air flow rates as shown.

3.3.18.5 Filters

A differential pressure switch across each filter shall initiate a filter alarm when the pressure drop across the filter reaches the setpoint as shown.

3.3.18.6 Freeze Protection

A freezestat, located as shown, shall stop the supply and return fans, cause the outside air, return air, and relief air dampers to return to their normal position, and shall initiate a low temperature alarm if the temperature drops below the freezestat's setpoint as shown. The DDC system shall monitor the freezestat through auxiliary contacts and shall indicate an alarm condition when the freezestat trips.

3.3.18.7 Cooling Coil Control

a. Occupied and Ventilation Delay Modes - The cooling coil control valve shall be modulated by the DDC system from the signal of a temperature sensing element and transmitter located in the coil discharge air to maintain the setpoint as shown.

b. Unoccupied Mode - The cooling coil control valve shall remain closed.

3.3.18.8 Minimum Outside Air Flow Control

a. Occupied Mode - The minimum outside air damper shall be modulated to maintain the minimum outside air flow at setpoint, as sensed by an air flow measurement station located in the minimum outside air duct.

b. Unoccupied and Ventilation Delay Modes - The minimum outside air damper shall remain closed.

3.3.18.9 Economizer and Mixed Air Temperature Control

The DDC system shall accept the signal of an outside air temperature sensing element and transmitter and the signal of a return air temperature sensing element and transmitter. When the return air temperature is above the economizer setpoint, and the outside air temperature is sufficiently below the return air temperature to be effective for cooling, the DDC system shall place the AHU in the economizer mode by modulating the economizer outside air, relief air, and the return air dampers to maintain the mixed air temperature at setpoint. As the economizer outside air and relief air dampers open, the return air damper closes. When the system is not in economizer mode, the economizer outside air and relief air dampers shall remain closed and the return air damper shall remain open.

3.3.18.10 Pressure Independent Terminal VAV Box with Velocity Controller

All Modes - The control damper of the VAV box shall modulate in response to the signal from a flow sensing element at the discharge or inlet of the VAV box to a microprocessor based VAV box velocity controller. The velocity controller shall control the box damper from the minimum flow position to the full flow position from the signal of a space temperature sensing element located as shown. When the space temperature decreases, the damper shall gradually close to the minimum flow position to maintain the cooling setpoint as shown. When the space temperature calls for heating after the minimum flow position is reached, control shall then pass through a temperature dead band as shown. When the space temperature has dropped through the dead band, the duct heater coil shall be gradually controlled to maintain the heating setpoint as shown.

3.3.18.11 Fan Powered Terminal VAV Box

a. Series Fan Powered Terminal Box. All Modes - The VAV box fan shall be energized from an upstream duct pressure switch confirming HVAC system fan operation. A space temperature sensing element, located as shown, acting through a microprocessor based VAV box controller, shall modulate the supply air control damper, mixing the supply air and recirculating room air to provide a constant volume of air to the space to maintain the cooling set point as shown until the supply air damper closes to minimum supply air flow. When the space temperature calls for heat after the supply air damper is closed to minimum flow and the VAV box is in maximum recirculation, control shall then pass through the temperature dead band. When the space temperature has dropped through the temperature dead band, the duct heater coil shall be gradually controlled to maintain the heating setpoint.

b. Parallel Fan Powered Terminal VAV Box. All Modes - A space temperature sensing element, located as shown, acting through a microprocessor based VAV box controller, shall modulate the supply air control damper to maintain the cooling setpoint as shown until the supply air damper closes to minimum supply air flow. When the space temperature calls for heat after the supply air damper is closed to minimum flow, control shall then pass through the temperature deadband, and the VAV box fan shall be energized. When the space temperature has dropped through a second temperature deadband, the duct heater coil shall be gradually controlled to maintain the heating setpoint.

3.3.18.12 Emergency Fan Shutdown

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NOTE: Smoke control is not addressed in this guide specification. Smoke control sequence of operation for each fan system, if beyond the requirements described, will be developed by the designer, based on the requirements and parameters of the project. The designer will account for operation of dampers and fans for pressurization and manual override of interlocks to the fire alarm system. All automatic overrides of normal HVAC control sequences will be activated through the fire protection and smoke control interface panel that the designer will design for the project.

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All Modes - Smoke detectors in the supply air and return air ductwork shall stop the supply fan and the return fan and initiate a smoke alarm if smoke is detected at either location. Restarting the supply fan and the return fan shall require manual reset at the smoke detector.

3.3.19 Single Zone with Hydronic Heating/Cooling Coils No Return Fan

3.3.19.1 Occupied, Unoccupied, and Ventilation Delay Modes of Operation

Ventilation delay mode timing shall start prior to the occupied mode timing. The DDC system shall prevent the outside air damper from opening. At the time shown, the DDC system shall place the system in the occupied mode. At the expiration of the ventilation delay mode timing period, the DDC system shall allow the outside air damper to open. At the time shown, the DDC system shall place the control system in the unoccupied mode of operation.

3.3.19.2 Outside Air, Return Air, and Relief Air Dampers

a. Occupied Mode - The outside air, return air, and relief air dampers shall be under space temperature and economizer control.

b. Unoccupied Mode - The dampers shall return to their normal positions.

c. Ventilation Delay Mode - The dampers shall return to their normal positions, except when under economizer control.

3.3.19.3 Supply Fan Control

a. Occupied and Ventilation Delay Modes - Supply fan [_____] shall start, and shall operate continuously.

b. Unoccupied Mode - The supply fan shall cycle according to the night setback schedule. The fan shall start and stop at the setpoints.

3.3.19.4 Filter

A differential pressure switch across the filter shall initiate a filter alarm when the pressure drop across the filter reaches the setpoint.

3.3.19.5 Freeze Protection

All Modes - A freezestat, located as shown, shall stop the supply fan, cause the outside air, return air, and relief air dampers to return to their normal position, and shall initiate a low temperature alarm if the temperature drops below the freezestat's setpoint. Return to the normal mode of operation shall require manual reset at the freezestat. The DDC system shall monitor the freezestat through auxiliary contacts and shall indicate an alarm condition when the freezestat trips.

3.3.19.6 Hydronic Cooling Coil

a. Occupied and Ventilation Delay Modes - The control valve shall be modulated by the DDC system from the signal of a space temperature sensor.

b. Unoccupied Mode - The DDC system shall close the cooling coil control valve.

3.3.19.7 Economizer Control

The DDC system shall accept the signal of an outside air temperature sensing element and transmitter and the signal of a return air temperature sensing element and transmitter. The DDC system shall perform switchover between outside air economizer control mode and minimum outside air mode. Until the return air temperature rises above the setpoint, the DDC system shall hold the system in the minimum outside air mode. When the return air temperature rises above the setpoint, the DDC system shall place the AHU in the economizer mode or in the minimum outside air mode, as determined by a comparison of the outside air and return air temperatures in accordance with the differential temperature setpoints. When the outside air temperature is low with respect to the return air temperature, the AHU shall be in the economizer mode. When the DDC system places the control system in the minimum outside air mode, the outside air damper shall be open to the minimum outdoor air setting.

3.3.19.8 Space Temperature Sequenced Heating and Cooling Control

When the DDC system is in the economizer mode, it shall maintain the setpoint from the signal of a space temperature sensor and transmitter. On a rise in space temperature, the DDC system shall first gradually close the heating coil valve. After passing through a deadband, the DDC system shall gradually operate the outside air damper to admit outside air beyond the minimum quantity and after the outside air damper is fully open the DDC system shall then operate the cooling coil valve to maintain the setpoint. When the DDC system is in the minimum outside air mode, the outside air damper shall be open to the minimum outside air setting. On a rise in space temperature, the DDC system shall first gradually close the heating coil valve. After passing through a deadband, the DDC system shall then gradually open the cooling coil valve to maintain the setpoint.

3.3.19.9   Emergency Fan Shutdown

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NOTE: Smoke control is not addressed in this guide specification. Smoke control sequence of operation for each fan system, if beyond the requirements described, will be developed by the designer, based on the requirements and parameters of the project. The designer will account for operation of dampers and fans for pressurization and manual override of interlocks to the fire alarm system. All automatic overrides of normal HVAC control sequences will be activated through the fire protection and smoke control interface panel that the designer will design for the project.

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All Modes - Smoke detectors in the supply air and return air ductwork shall stop the supply fan and initiate a smoke alarm if smoke is detected at either location. Restarting the supply fan shall require manual reset at the smoke detector.

3.3.20   Single Zone with Dual-Temperature Coil; No Return Fan

3.3.20.1   Occupied, Unoccupied, and Ventilation Delay Modes of Operation

Ventilation delay mode timing shall start prior to the occupied mode timing. The DDC system shall prevent the outside air damper from opening. At the time shown, the DDC system shall place the system in the occupied mode. At the expiration of the ventilation delay mode timing period, the DDC system shall allow the outside air damper to open. At the time shown, the DDC system shall place the control system in the unoccupied mode of operation.

3.3.20.2   Outside Air, Return Air, and Relief Air Dampers

a. Occupied Mode - The outside air, return air, and relief air dampers shall be under space temperature and economizer control.

b. Unoccupied Mode - The dampers shall return to their normal positions.

c. Ventilation Delay Mode - The dampers shall return to their normal positions, except when under economizer control.

3.3.20.3   Supply Fan Control

a. Occupied and Ventilation Delay Modes - Supply fan [_____] shall start, and shall operate continuously.

b. Unoccupied Mode - The supply fan shall cycle according to the night setback schedule. The fan shall start and stop at the setpoints as shown.

3.3.20.4 Filter

A differential pressure switch across the filter shall initiate a filter alarm when the pressure drop across the filter reaches the setpoint as shown.

3.3.20.5 Freeze Protection

All Modes - A freezestat, located as shown, shall stop the supply fan, cause the outside air, return air, and relief air dampers to return to their normal position, and shall initiate a low temperature alarm if the temperature drops below the freezestat's setpoint. Return to the normal mode of operation shall require manual reset at the freezestat. The DDC system shall monitor the freezestat through auxiliary contacts and shall indicate an alarm condition when the freezestat trips.

3.3.20.6 Dual-Temperature Coil Changeover Control

The DDC panel shall select the heating and cooling modes based on input from a temperature sensor and transmitter located in the dual-temperature supply. When the dual-temperature supply temperature is above the setpoint, the DDC panel shall operate the dual-temperature coil valve as a heating coil valve in sequence with the outside air, return air, and relief air dampers. When the dual-temperature supply temperature is below the setpoint, the DDC system shall operate the dual-temperature coil valve as a cooling coil valve in sequence with the outside air, return air, and relief air dampers.

3.3.20.7 Economizer Control

The DDC system shall accept the signal of an outside air temperature sensing element and transmitter and the signal of a return air temperature sensing element and transmitter. The DDC system shall perform switchover between outside air economizer control mode and minimum outside air mode. Until the return air temperature rises above the setpoint, the DDC system shall hold the system in the minimum outside air mode. When the return air temperature rises above the setpoint, the DDC system shall place the AHU in the economizer mode or in the minimum outside air mode, as determined by a comparison of the outside air and return air temperatures in accordance with the differential temperature setpoints. When the outside air temperature is low with respect to the return air temperature, the AHU shall be in the economizer mode. When the DDC system places the control system in the minimum outside air mode, the outside air damper shall be open to the minimum outdoor air setting.

3.3.20.8 Space Temperature Sequenced Heating Control

When the DDC system is in the economizer mode, it shall maintain the setpoint from the signal of a space temperature sensor and transmitter. On a rise in space temperature, the DDC system shall first gradually close the coil valve. After passing through a deadband, the DDC system shall then gradually operate the outside air damper to admit outside air beyond the minimum quantity to maintain the setpoint as shown. When the DDC system is in the minimum outside air mode, the outside air damper shall be open to the minimum outside air setting. On a rise in space temperature, the DDC system shall gradually close the coil valve to maintain the setpoint as shown.

3.3.20.9   Space Temperature Sequenced Cooling Control

When the DDC system is in the economizer mode, it shall maintain the setpoint from the signal of a space temperature sensor and transmitter. On a rise in space temperature, the DDC system shall first gradually open the outside air damper to admit outside air beyond the minimum quantity. When the outside air damper is fully open, on a further rise in space temperature, the DDC system shall gradually open the coil valve. When the DDC system is in the minimum outside air mode, the outside air damper shall be open to the minimum outside air setting. On a rise in space temperature, the DDC system shall gradually open the coil valve to maintain the setpoint.

3.3.20.10   Emergency Fan Shutdown

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NOTE: Smoke control is not addressed in this guide specification. Smoke control sequence of operation for each fan system, if beyond the requirements described, will be developed by the designer, based on the requirements and parameters of the project. The designer will account for operation of dampers and fans for pressurization and manual override of interlocks to the fire alarm system. All automatic overrides of normal HVAC control sequences will be activated through the fire protection and smoke control interface panel that the designer will design for the project.

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All Modes - Smoke detectors in the supply air and return air ductwork shall stop the supply fan and initiate a smoke alarm if smoke is detected at either location. Restarting the supply fan shall require manual reset at the smoke detector.

3.3.21   Single Zone Control with Humidity Control; No Return Fan

3.3.21.1   Occupied, Unoccupied, and Ventilation Delay Modes of Operation

Ventilation delay mode timing shall start prior to the occupied mode timing. The DDC system shall prevent the outside air damper from opening. At the time shown, the DDC system shall place the system in the occupied mode. At the expiration of the ventilation delay mode timing period, the DDC system shall allow the outside air damper to open. At the time shown, the DDC system shall place the control system in the unoccupied mode of operation.

3.3.21.2   Outside Air Damper

a. Occupied Mode - The outside air damper shall open.

b. Unoccupied and Ventilation Delay Modes - The damper shall close.

3.3.21.3   Supply Fan Control

a. Occupied and Ventilation Delay Modes - Supply fan [_____] shall start, and shall operate continuously.

b. Unoccupied Mode - The supply fan shall cycle according to the night setback schedule. The fan shall start and stop at the setpoints.

3.3.21.4 Filter

Differential pressure switch across the filter shall initiate a filter alarm when the pressure drop across the filter reaches the setpoint.

3.3.21.5 Outside Air Preheat-Coil Control

All Modes - The DDC system shall modulate the control valve from the signal of a temperature sensing element and transmitter in the coil discharge air to maintain the setpoint.

3.3.21.6 Freeze Protection

All Modes - A freezestat, located as shown, shall stop the supply fan, cause the outside air, return air, and relief air dampers to return to their normal position, and shall initiate a low temperature alarm if the temperature drops below the freezestat's setpoint. Return to the normal mode of operation shall require manual reset at the freezestat. The DDC system shall monitor the freezestat through auxiliary contacts and shall indicate an alarm condition when the freezestat trips.

3.3.21.7 Cooling Coil

a. Occupied and Ventilation Delay Modes - The DDC system shall compare the signals of a space temperature sensor/transmitter and space relative humidity sensor/transmitter to operate the cooling coil valve. Based on the highest signal received, the DDC system shall modulate the valve to maintain space temperature or space relative humidity.

b. Unoccupied Mode - The DDC system shall close the cooling coil control valve.

3.3.21.8 Humidity Control

a. Occupied Mode - The DDC system shall accept the signals from a space relative humidity sensor and a duct relative humidity sensor to control the humidifier valve and the cooling coil valve. The DDC system shall gradually open the cooling coil valve in the event that the space relative humidity continues to rise after the humidifier valve is closed. The DDC system shall gradually operate the humidifier valve from the signal of a space relative humidity sensor/transmitter to maintain relative humidity setpoint. The DDC system shall receive a signal from a relative humidity sensor/transmitter in the ductwork downstream of the humidifier and shall limit the relative humidity at that point to a high-limit relative humidity setpoint.

b. Unoccupied and Ventilation Delay Modes - The humidifier valve shall be closed.

3.3.21.9 Constant Temperature Hydronic Heating Control

All Modes - The DDC system shall accept a signal from a temperature sensing element and transmitter in the heating supply line, and shall modulate the system control valve to maintain the setpoint.

3.3.21.10 Reheat

All Modes - The DDC system shall gradually close the reheat coil valve on a rise in space temperature to maintain the setpoint.

3.3.21.11 Emergency Fan Shutdown

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NOTE: Smoke control is not addressed in this guide specification. Smoke control sequence of operation for each fan system, if beyond the requirements described, will be developed by the designer, based on the requirements and parameters of the project. The designer will account for operation of dampers and fans for pressurization and manual override of interlocks to the fire alarm system. All automatic overrides of normal HVAC control sequences will be activated through the fire protection and smoke control interface panel that the designer will design for the project.

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All Modes - Smoke detectors in the supply air and return air ductwork shall stop the supply fan and initiate a smoke alarm if smoke is detected at either location. Restarting the supply fan shall require manual reset at the smoke detector.

3.3.22 Single Zone Hydronic Heating and Direct Expansion Cooling Coil

3.3.22.1 Occupied, Unoccupied, and Ventilation Delay Modes

Ventilation delay mode timing shall start prior to the occupied mode timing. The DDC system shall prevent the outside air damper from opening. At the time shown, the DDC system shall place the system in the occupied mode. At the expiration of the ventilation delay mode timing period, the DDC system shall allow the outside air damper to open. At the time shown, the DDC system shall place the control system in the unoccupied mode of operation.

3.3.22.2 Outside Air, Return Air, and Relief Air Dampers

a. Occupied Mode - The outside air, return air, and relief air dampers shall be under mixed air temperature and economizer control.

b. Unoccupied Mode - The dampers shall return to their normal positions.

c. Ventilation Delay Mode - The dampers shall return to their normal positions, except when under economizer control.

3.3.22.3 Supply Fan Control

a. Occupied and Ventilation Delay Modes - Supply fan [_____] shall start and shall operate continuously.

b. Unoccupied Mode - The supply fan shall cycle according to the night setback schedule. The fan shall start and stop at the setpoints shown.

3.3.22.4 Filter

A differential pressure switch across the filter shall initiate a filter alarm when the pressure drop across the filter reaches the setpoint.

3.3.22.5 Freeze Protection

All Modes - A freezestat, located as shown, shall stop the supply fan, cause the outside air, return air, and relief air dampers to return to their normal position, and shall initiate a low temperature alarm if the temperature drops below the freezestat's setpoint. Return to the normal mode of operation shall require manual reset at the freezestat. The DDC system shall monitor the freezestat through auxiliary contacts and shall indicate an alarm condition when the freezestat trips.

3.3.22.6 Direct Expansion Cooling Coil

a. Occupied and Ventilation Delay Modes - The stages of cooling shall be controlled according to the space temperature.

b. Unoccupied Mode - Cooling shall be off.

3.3.22.7 Economizer Control

The DDC system shall accept the signal of an outside air temperature sensing element and transmitter and the signal of a return air temperature sensing element and transmitter. The DDC system shall perform switchover between outside air economizer control mode and minimum outside air mode. Until the return air temperature rises above the setpoint, the DDC system shall hold the system in the minimum outside air mode. When the return air temperature rises above the setpoint, the DDC system shall place the AHU in the economizer mode or in the minimum outside air mode, as determined by a comparison of the outside air and return air temperatures in accordance with the differential temperature setpoints. When the outside air temperature is low with respect to the return air temperature, the AHU shall be in the economizer mode. When the DDC system places the control system in the minimum outside air mode, the outside air damper shall be open to the minimum outdoor air setting.

3.3.22.8 Space Temperature Sequenced Heating and Cooling Control

When the DDC system is in the economizer mode, it shall maintain the setpoint as shown from the signal of a space temperature sensor and transmitter. On a rise in space temperature, the DDC system shall first gradually close the heating coil valve. After passing through a deadband, the DDC system shall gradually operate the outside air damper to admit outside air beyond the minimum quantity and after the outside air damper is fully open the DDC system shall operate the stages of cooling in sequence. When the DDC system is in the minimum outside air mode, the outside air damper shall be open to the minimum outside air setting. On a rise in space temperature, the DDC system shall first gradually close the heating coil valve. After passing through a deadband, the DDC system shall operate the stages of cooling in sequence.

3.3.22.9 Emergency Fan Shutdown

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NOTE: Smoke control is not addressed in this guide specification. Smoke control sequence of operation for each fan system, if beyond the requirements described, will be developed by the designer, based on the requirements and parameters of the project. The designer will account for operation of dampers and fans for pressurization and manual override of interlocks to the fire alarm system. All automatic overrides of normal HVAC control sequences will be activated through the fire protection and smoke control interface panel that the designer will design for the project.

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All Modes - Smoke detectors in the supply air and return air ductwork shall stop the supply fan and initiate a smoke alarm if smoke is detected at either location. Restarting the supply fan shall require manual reset at the smoke detector.

3.4 COMMISSIONING PROCEDURES

3.4.1 Evaluations

The Contractor shall make the observations, adjustments, calibrations, measurements, and tests of the control systems, set the time schedule, and make any necessary control system corrections to ensure that the systems function as described in the sequence of operation.

3.4.1.1 Item Check

Signal levels shall be recorded for the extreme positions of each controlled device. An item-by-item check of the sequence of operation requirements shall be performed using Steps 1 through 4 in the specified control system commissioning procedures. Steps 1, 2, and 3 shall be performed with the HVAC system shut down; Step 4 shall be performed after the HVAC systems have been started. External input signals to the DDC system (such as starter auxiliary contacts, and external systems) may be simulated in steps 1, 2, and 3. With each operational mode signal change, DDC system output relay contacts shall be observed to ensure that they function.

3.4.1.2 Weather Dependent Test Procedures

Weather dependent test procedures that cannot be performed by simulation shall be performed in the appropriate climatic season. When simulation is used, the actual results shall be verified in the appropriate season.

3.4.1.3 Two-Point Accuracy Check

A two-point accuracy check of the calibration of each HVAC control system sensing element and transmitter shall be performed by comparing the DDC system readout to the actual value of the variable measured at the sensing element and transmitter or airflow measurement station location. Digital indicating test instruments shall be used, such as digital thermometers, motor-driven psychrometers, and tachometers. The test instruments shall be at least twice as accurate as the specified sensing element-to-DDC system readout accuracy. The calibration of the test instruments shall be traceable to National Institute Of Standards And Technology standards. The first check point shall be with the HVAC system in the shutdown condition, and the second check point shall be with the HVAC system in an operational condition. Calibration checks shall verify that the sensing element-to-DDC system readout accuracies at two points are within the specified product accuracy tolerances. If not, the device shall be recalibrated or replaced and the calibration check repeated.

3.4.1.4 Insertion and Immersion Temperatures

Insertion temperature and immersion temperature sensing elements and transmitter-to-DDC system readout calibration accuracy shall be checked at one physical location along the axis of the sensing element.

3.4.1.5 Averaging Temperature

Averaging temperature sensing element and transmitter-to-DDC system readout calibration accuracy shall be checked every 2 feet along the axis of the sensing element in the proximity of the sensing element, for a maximum of 10 readings. These readings shall then be averaged.

3.4.2 Space Temperature Controlled Perimeter Radiation

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NOTE: Delete commissioning procedures for system types which are not applicable to the project.
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The heating medium shall be turned on, and the thermostat temperature setpoint shall be raised. The valve shall open. The thermostat temperature shall be lowered and the valve shall close. The thermostat shall be set at the setpoint shown.

3.4.3 Unit Heater and Cabinet Unit Heater

The "OFF/AUTO" switch shall be placed in the "OFF" position. Each space thermostat temperature setting shall be turned up so that it makes contact to turn on the unit heater fans. The unit heater fans shall not start. The "OFF/AUTO" switch shall be placed in the "AUTO" position. It shall be ensured that the unit heater fans start. Each space thermostat temperature setting shall be turned down, and the unit heater fans shall stop. The thermostats shall be set at their temperature setpoints. The results of testing of one of each type of unit shall be logged.

3.4.4 Gas-Fired Infrared Heater

Each space thermostat temperature setting shall be turned up so that it makes contact to turn on the infrared heater; it shall be ensured that the heater turns on. Each space thermostat temperature shall be turned down and it shall be ensured that the infrared heater turns off. The thermostats shall be set at their temperature setpoints. The results of testing of one of each type of unit shall be logged.

3.4.5 All-Air Small Packaged Unitary

The schedules shall be manually entered for day temperature and night temperature setpoints as shown. The fan "AUTO/ON" switch shall be set to

"ON." The time shall be manually entered as "DAY." The "HEATING/COOLING" switch shall be set to "HEATING" and it shall be ensured that cooling is off. The temperature setpoint shall be raised and it shall be ensured that heating starts. The "HEATING/COOLING" switch shall be set to "COOLING" and it shall be ensured that heat is off. The temperature setpoint shall be lowered and it shall be ensured that cooling starts. The fan "AUTO/ON" switch shall be set to "AUTO" and the foregoing procedure repeated. The fan shall start and stop automatically with the starting and stopping of heating and cooling. The time shall be manually entered as "NIGHT." The foregoing procedures shall be repeated. When the system is verified as operational, the correct "DAY" and "NIGHT" temperature settings shall be restored and the correct time restored. The power to the thermostat shall be shut off and it shall be verified that the thermostat clock keeps time. The results of testing of one of each type of unit shall be logged.

3.4.6 Fan Coil Unit

The dual-temperature hydronic system shall be set to heating. Each space thermostat temperature setting shall be turned up so that it makes contact and turns the fan coil unit on. It shall be ensured that the fan coil unit fan starts and the valves open to flow through the coils. Each space thermostat temperature setting shall be turned down and it shall be ensured that the fan coil unit fans stop. It shall be ensured that the valves close to flow through the coils. The dual-temperature hydronic system shall be switched to cooling. Each space thermostat temperature setting shall be turned up and it shall be ensured that contact is broken and the fan coil unit fans stop. It shall be ensured that the valves close to flow through the coil. Each space thermostat temperature setting shall be turned down. It shall be ensured that the fan coil unit fans start and the valves open to flow through the coils. The thermostats shall be set at their temperature setpoints. The results of testing of one of each type of unit shall be logged.

3.4.7 Central Plant Hydronic Heating with Steam/Hot Water Converter

Installation shall be as follows:

a. Step 1 - System Inspection: The HVAC system shall be observed in its shutdown condition. Power and main air shall be available where required. The converter valve shall be closed.

b. Step 2 - Calibration Accuracy Check with HVAC System Shutdown: Readings shall be taken with a digital thermometer at each temperature sensing element location. Each temperature shall be read at the DDC controller, and the thermometer and DDC system readings logged. The calibration accuracy of the sensing element-to-DDC system readout for outside air temperature and hydronic system supply temperature shall be checked.

c. Step 3 - Actuator Range Adjustments: A signal shall be applied to the actuator, through an operator entered value to the DDC system. The proper operation of the actuators and positions for all valves shall be verified. The signal shall be varied from live zero to full range, and it shall be verified that the actuators travel from zero stroke to full stroke within the signal range. It shall be verified that all sequenced actuators move from zero stroke to full stroke in the proper direction and move the connected device in the proper direction from one extreme position to the other.

d. Step 4 - Control System Commissioning:

(1) The two-point calibration sensing element-to-DDC system readout accuracy check for the outside air temperature shall be performed. Any necessary software adjustments to setpoints or parameters shall be made to achieve the outside air temperature schedule.

(2) A signal shall be applied to simulate that the outside air temperature is above the setpoint. It shall be verified that pump [_____] stops. A signal shall be applied to simulate that the outside air temperature is below the setpoint. It shall be verified that pump [_____] starts.

(3) The two-point calibration accuracy check of the sensing element-to-DDC system readout for the system supply temperature shall be performed. The system supply temperature setpoint shall be set for the temperature schedule as shown. Signals of 8 ma and 16 ma shall be sent to the DDC system from the outside air temperature sensor, to verify that the supply temperature setpoint changes to the appropriate values.

(4) The control system shall be placed in the occupied mode. The calibration accuracy check of sensing element-to-DDC system readout shall be performed for each space temperature sensor and the values logged. Each space temperature setpoint shall be set as shown. The control system shall be placed in the unoccupied mode, and it shall be verified that each space temperature setpoint changes to the unoccupied mode setting.

3.4.8 Single Building Hydronic Heating with Hot Water Boiler

Steps for installation shall be as follows:

a. Step 1 - System Inspection: The HVAC system shall be observed in its shutdown condition. It shall be verified that power and main air are available where required.

b. Step 2 - Calibration Accuracy Check with HVAC System Shutdown: Readings shall be taken with a digital thermometer at each temperature sensing element location. Each temperature shall be read at the DDC controller, and the thermometer and DDC system readings logged. The calibration accuracy of the sensing element-to-DDC system readout for outside air temperature and system supply temperature shall be checked.

c. Step 3 - Actuator Range Adjustments: A signal shall be applied to the actuator through an operator entered value to the DDC system. The proper operation of the actuators and positioners for all valves shall be verified visually. The signal shall be varied from live zero to full range, and it shall be verified that the actuators travel from zero stroke to full stroke within the signal range. It shall be verified that all sequenced actuators move from zero stroke to full stroke in the proper direction, and move the connected device in the proper direction from one extreme position to the other.

d. Step 4 - Control System Commissioning:

(1) The two-point calibration sensing element-to-DDC system readout accuracy check for the outside air temperature shall be performed. Any necessary software adjustments to setpoints or parameters shall be made to achieve the outside air temperature schedule.

(2) The outside air temperature shall be simulated through an operator entered value to be above the setpoint. It shall be verified that pumps [_____] and boiler [_____] stop. A value shall be entered to simulate that the outside air temperature is below the setpoint as shown. It shall be verified that pumps [_____] start and boiler [_____] operates.

(3) The two-point calibration accuracy check of the sensing element-to-DDC system readout for the hydronic system supply temperature shall be performed. The supply temperature setpoint shall be set for the temperature schedule as shown. Signals of 8 ma and 16 ma shall be sent to the DDC system from the outside air temperature sensor, to verify that the supply temperature setpoint changes to the appropriate values.

(4) The control system shall be placed in the occupied mode. The calibration accuracy check of sensing element-to-DDC system readout shall be performed for each space temperature sensor and the values logged. Each space temperature setpoint shall be set as shown. The control system shall be placed in the unoccupied mode, and it shall be verified that each space temperature setpoint changes to the unoccupied mode setting.

3.4.9 Central Plant High Temperature Hot Water Hydronic Heating

Steps for installation shall be as follows:

a. Step 1 - System Inspection: The HVAC system shall be observed in its shutdown condition. It shall be verified that power and main air are available where required and that the converter valve is closed.

b. Step 2 - Calibration Accuracy Check with HVAC System Shutdown: Readings shall be taken with a digital thermometer at each temperature sensing element location. Each temperature shall be read at the DDC controller, and the thermometer and DDC system readings logged. The calibration accuracy of the sensing element-to-DDC system readout for outside air temperature and system supply temperature shall be checked.

c. Step 3 - Actuator Range Adjustments: A signal shall be applied to the actuator through an operator entered value to the DDC system. The proper operation of the actuators and positioners for all valves shall be verified. The signal shall be varied from live zero to full range, and it shall be verified that the actuators travel from zero stroke to full stroke within the signal range. It shall be verified that all sequenced actuators move from zero stroke to full stroke in the proper direction, and move the connected device in the proper direction from one extreme position to the other.

d. Step 4 - Control System Commissioning:

(1) The two-point calibration sensing element-to-DDC system readout accuracy check for the outside air temperature shall be

performed. Any necessary software adjustments shall be made to setpoints or parameters to achieve the outside air temperature schedule.

(2) The outside air temperature shall be simulated through an operator entered value to be above the setpoint. It shall be verified that pump [_____] stops and the high-temperature hot-water control valve closes. A value shall be entered to simulate that the outside air temperature is below the setpoint as shown. It shall be verified that pump [_____] starts.

(3) The two-point calibration accuracy check of the sensing element-to-DDC system readout for the hydronic system supply temperature shall be performed. The supply temperature setpoint shall be set for the temperature schedule as shown. Signals of 8 ma and 16 ma shall be sent to the DDC system from the outside air temperature sensor, to verify that the supply temperature setpoint changes to the appropriate values. A high temperature condition shall be initiated in the hydronic system supply line by lowering the thermostat setting. It shall be verified that the high-temperature hot water shutoff valve closes and an alarm is initiated. The thermostat shall be set at the setting shown, the safety circuit shall be manually reset, and it shall be verified that the shutoff valve opens and a return-to-normal signal is sent.

(4) The control system shall be placed in the occupied mode. The calibration accuracy check of sensing element-to-DDC system readout shall be performed for each space temperature sensor and the values logged. Each space temperature setpoint shall be set as shown. The control system shall be placed in the unoccupied mode, and it shall be verified that each space temperature setpoint changes to the unoccupied mode setting.

3.4.10 Central Plant Dual Temperature Hydronic

Steps for installation shall be as follows:

a. Step 1 - System Inspection: The HVAC system shall be observed in its shutdown condition. The system shall be checked to see that power and main air are available where required, and that the converter steam hot water control valve is closed.

b. Step 2 - Calibration Accuracy Check with HVAC System Shutdown: Readings shall be taken with a digital thermometer at each temperature sensing element location. Each temperature shall be read at the DDC controller, and the thermometer and DDC system readings logged. The calibration accuracy of the sensing element-to-DDC system readout for outside air temperature, hydronic system supply and return temperatures shall be checked.

c. Step 3 - Actuator Range Adjustments: A signal shall be applied to the actuator through an operator entered value to the DDC system. The proper operation of the actuators and positioners for all valves shall be visually verified. The signal shall be varied from live zero to full range, and it shall be verified that the actuators travel from zero stroke to full stroke within the signal range. It shall be verified that all sequenced actuators move from zero stroke to full stroke in the proper direction, and move the connected device in the proper direction from one extreme position to the other.

d. Step 4 - Control System Commissioning:

(1) The two-point calibration sensing element-to-DDC system readout accuracy check for the outside air temperature shall be performed. Any necessary software adjustments shall be made to setpoints or parameters to achieve the outside air temperature schedule.

(2) The control system shall be indexed to the heating mode and it shall be verified that the changeover valves open to flow through the converter and close to flow from central plant chilled water.

(3) The outside air temperature shall be simulated through an operator entered value to be above the setpoint. It shall be verified that pump [_____] stops. A value shall be entered to simulate that the outside air temperature is below the setpoint. It shall be verified that pump [_____] starts.

(4) The two-point calibration accuracy check of the sensing element-to-DDC system readout for the hydronic system supply temperature shall be performed. The supply temperature shall be set for the temperature schedule. Signals of 8 ma and 16 ma shall be sent to the DDC system from the outside air temperature sensor, to verify that the supply temperature setpoint changes to the appropriate values.

(5) The two-point accuracy check of the sensing element-to-DDC system readout for the hydronic system return temperature shall be performed. The return water temperature setpoint shall be set to the setpoint. The system shall be placed in the unoccupied mode.

(6) The control system shall be indexed to the cooling mode. It shall be verified that the converter control valve closes and that pump [_____] continues to operate until the return water temperature falls below its setpoint. It shall be verified that when the return water temperature falls below the setpoint that the changeover valves close to flow through the converter and open to flow from central plant chilled water and that Pump [_____] stops.

(7) The control system shall be placed in the occupied mode and it shall be verified that pump [_____] starts.

3.4.11 Central Plant High Temperature Hot Water Dual Temperature Hydronic

Steps for installation shall be as follows:

a. Step 1 - System Inspection: The HVAC system shall be observed in its shutdown condition. The system shall be checked to see that power and main air are available where required, and that the converter high temperature hot water control valve is closed.

b. Step 2 - Calibration Accuracy Check with HVAC System Shutdown: Readings shall be taken with a digital thermometer at each temperature sensing element location. Each temperature shall be read at the DDC controller, and the thermometer and DDC system readings logged. The calibration accuracy of the sensing element-to-DDC system readout for outside air temperature and hydronic system supply temperature shall be checked.

c. Step 3 - Actuator Range Adjustments: A signal shall be applied to the actuator through an operator entered value to the DDC panel. The proper operation of the actuators and positioners for all valves shall be visually verified. The signal shall be varied from live zero to full range, and it shall be verified that the actuators travel from zero stroke to full stroke within the signal range. It shall be verified that all sequenced actuators move from zero stroke to full stroke in the proper direction, and move the connected device in the proper direction from one extreme position to the other.

d. Step 4 - Control System Commissioning:

(1) The two-point calibration sensing element-to-DDC system readout accuracy check for the outside air temperature shall be performed. Any necessary software adjustments shall be made to setpoints or parameters to achieve the outside air temperature schedule.

(2) The control system shall be indexed to the heating mode and it shall be verified that the changeover valves open to flow through the converter and close to flow from central plant chilled water.

(3) The outside air temperature shall be simulated through an operator entered value to be above the setpoint. It shall be verified that pump [_____] stops and the high-temperature hot water shutoff valve closes. A value shall be entered to simulate that the outside air temperature is below the setpoint as shown. It shall be verified that pump [_____] starts.

(4) The two-point calibration accuracy check of the sensing element-to-DDC system readout for the hydronic system supply temperature shall be performed. The supply temperature setpoint shall be set for the temperature schedule. Signals of 8 ma and 16 ma shall be sent to the DDC system from the outside air temperature sensor, to verify that the supply temperature setpoint changes to the appropriate values.

(5) The two-point accuracy check of the sensing element-to-DDC system readout for the hydronic system return temperature shall be performed. The return water temperature setpoint shall be set to the setpoint. The control system shall be placed in the unoccupied mode.

(6) The control system shall be indexed to the cooling mode. It shall be verified that the converter control valve closes and that pump [_____] continues to operate until the return water temperature falls below its setpoint. It shall be verified that when the return water temperature falls below the setpoint, the changeover valves close to flow through the converter and open to flow from central plant chilled water and that Pump [_____] stops.

(7) The control system shall be placed in the occupied mode and it shall be verified that pump [_____] starts.

3.4.12 Single Building Dual Temperature Hydronic

Steps for installation shall be as follows:

a. Step 1 - System Inspection: The HVAC system shall be observed in its shutdown condition. It shall be verified that power and main air are available where required.

b. Step 2 - Calibration Accuracy Check with HVAC System Shutdown: Readings shall be taken with a digital thermometer at each temperature sensing element location. Each temperature shall be read at the DDC controller, and the thermometer and DDC system readings logged. The calibration accuracy of the sensing element-to-DDC system readout for outside air temperature, hydronic system supply and return temperatures shall be checked.

c. Step 3 - Actuator Range Adjustments: A signal shall be applied to the actuator, through an operator entered value. The proper operation of the actuators and positioners for all valves shall be visually verified. The signal shall be varied from live zero to full range, and actuator travel from zero stroke to full stroke within the signal range shall be verified. It shall be verified that all sequenced actuators move from zero stroke to full stroke in the proper direction, and move the connected device in the proper direction from one extreme position to the other.

d. Step 4 - Control System Commissioning:

(1) The two-point calibration sensing element-to-DDC system readout accuracy check for the outside air temperature shall be performed. Any necessary software adjustments shall be made to setpoints or parameters to achieve the outside air temperature schedule.

(2) The control system shall be indexed to the heating mode and it shall be verified that chiller [_____] is shut down and that distribution pump [_____] continues to operate until the time delay expires. It shall be verified that the changeover valves open to flow through boiler [_____] and close to flow through chiller [_____] upon expiration of the time delay.

(3) The outside air temperature shall be simulated to be above the setpoint through an operator entered value. It shall be verified that distribution pump [_____] stops, boiler [_____] is stopped, [boiler pump [_____] is stopped,] and control of the hydronic heating system control valve is disabled. A value shall be entered to simulate that the outside air temperature is below the setpoint. It shall be verified that distribution pump [_____] starts, boiler [_____] is started, [boiler pump [_____] is started,] and control of the hydronic heating system control valve is enabled.

(4) The two-point calibration accuracy check of the sensing element-to-DDC system readout for the hydronic system supply temperature shall be performed. The supply temperature setpoint shall be set for the temperature schedule as shown. Signals of 8

ma and 16 ma shall be sent to the DDC system from the outside air temperature sensor, to verify that the supply temperature setpoint changes to the appropriate values.

(5) The two-point accuracy check of sensing element-to-DDC system readout for the hydronic system return temperature shall be performed. It shall be verified that the return water temperature setpoint is set to the setpoint. The control system shall be placed in the unoccupied mode.

(6) The control system shall be indexed to the cooling mode. It shall be verified that boiler [_____] shuts down, [boiler pump [_____] shuts down,] and distribution pump [_____] continues to operate until the return water temperature falls below its setpoint. It shall be verified that when the return water temperature falls below its setpoint that the changeover valves close to flow through the boiler [_____] and open to flow through chiller [_____] and distribution pump [_____] stops.

(7) The control system shall be placed in the occupied mode and it shall be verified that distribution pump [_____] starts and chiller operation is enabled.

(8) The control system shall be placed in the unoccupied mode and it shall be verified that chiller [_____] shuts down and distribution pump [_____] continues to operate until the expiration of the time delay and then stops.

3.4.13 Heating and Ventilating Unit

Steps for installation are as follows:

a. Step 1 - System Inspection: The HVAC system shall be observed in its shutdown condition. The system shall be checked to see that power and main air are available where required, the outside air damper and relief air damper are closed, and the return air damper is open.

b. Step 2 - Calibration Accuracy Check with HVAC System Shutdown: Readings shall be taken with a digital thermometer at each temperature sensing element location. Each temperature shall be read at the DDC controller, and the thermometer and DDC system readings logged. The calibration accuracy of the sensing element-to-DDC system readout for space temperature shall be checked.

c. Step 3 - Actuator Range Adjustments: A signal shall be applied to the actuator through an operator entered value to the DDC system. The proper operation of the actuators and positioners for all dampers and valves shall be verified. The signal shall be varied from live zero to full range, and that the actuators travel from zero stroke to full stroke within the signal range shall be verified. It shall be verified that all sequenced and parallel-operated actuators move from zero stroke to full stroke in the proper direction, and move the connected device in the proper direction from one extreme position to the other.

d. Step 4 - Control System Commissioning:

(1) With the fan ready to start, the system shall be placed in

the ventilation delay mode and in the occupied mode through operator entered values. It shall be verified that supply fan [_____] starts. It shall be verified that the outside air and relief air dampers are closed, the return air damper is open, and the heating coil valve is under control, by artificially changing the space temperature through operator entered values. The system shall be placed out of the ventilation delay mode, and it shall be verified that the outside air, return air, and relief air dampers come under control by simulating a change in space temperature.

(2) The control system shall be placed in the minimum outside air mode. It shall be verified that the outside air damper opens to minimum position.

(3) The calibration accuracy check of sensing element-to-DDC system readout for the space temperature shall be performed. The space temperature setpoint shall be set as shown.

(4) The control system shall be placed in the unoccupied mode, and it shall be verified that the HVAC system shuts down, and the control system assumes the specified shutdown conditions. The space temperature shall be artificially changed to below the night setback setpoint, and it shall be verified that the HVAC system starts; the space temperature shall be artificially changed to above the night setback setpoint, and it shall be verified that the HVAC system stops. The night setback temperature setpoint shall be set as shown.

(5) With the HVAC system running, a filter differential pressure switch input signal shall be simulated, at the device. It shall be verified that the filter alarm is initiated. The differential pressure switch shall be set at the setpoint as shown.

(6) With the HVAC system running, a freezestat trip input signal shall be simulated at the device. HVAC system shutdown shall be verified. It shall be verified that a low temperature alarm is initiated. The freezestat shall be set at the setpoint. The HVAC system shall be restarted by manual restart and it shall be verified that the alarm returns to normal.

(7) With the HVAC system running, a smoke detector trip input signal shall be simulated at each detector, and verification of control device actions and interlock functions as described in the Sequence of Operation shall be made. Simulation shall be performed without false-alarming any Life Safety systems. It shall be verified that the HVAC system shuts down and that the smoke detector alarm is initiated. The detectors shall be reset. The HVAC system shall be restarted by manual reset, and it shall be verified that the alarm signal is changed to a return-to-normal signal.

3.4.14 Multizone Control System with Return Fan

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NOTE: For subparagraph d, step 4 below, in a two-deck multizone system, given that there is no deadband between heating and cooling, reliable operation of the economizer cycle may be difficult

to achieve. An economizer cycle should only be used in this system if the unit is either served by a dual-temp hydronic system, or HW and CHW availability is scheduled (i.e.-only HW is available during the heating season and vice versa). If HW and CHW are both available year-round, then an economizer cycle should not be used. The following commissioning procedures should be edited accordingly. (See TI 810-11 for further details on this subject.)

When an economizer cycle is not to be used, delete subparagraph d, step 4, subparagraph (3).

In subparagraph d, step 4, subparagraph (4), outside-air reset of the hot-deck discharge temperature setpoint should not be used in conjunction with outside air reset of the heating water supply temperature. If outside air reset of the hot-deck discharge temperature is not being performed, delete this paragraph and the paragraph that follows.

If outside air reset of the hot-deck discharge temperature is being performed, delete subparagraph d, step 4, subparagraph (6).
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Steps for installation shall be as follows:

a. Step 1 - System Inspection: The HVAC system shall be observed in its shutdown condition. The system shall be checked to see that power and main air are available where required; that the outside air damper, relief air damper, and cooling coil valve are closed; and that the return air damper is open.

b. Step 2 - Calibration Accuracy Check with HVAC System Shutdown: Readings shall be taken with a digital thermometer at each temperature-sensing element location. Each temperature shall be read at the DDC controller, and the thermometer and DDC system readings logged. The calibration accuracy of the sensing element-to-DDC system readout for outside air, return air, mixed air, cold-deck, and hot-deck temperatures shall be checked.

c. Step 3 - Actuator Range Adjustments: A signal shall be applied to the actuator through an operator entered value to the DDC system. The proper operation of the actuators and positioners for all dampers and valves shall be verified. The signal shall be varied from live zero to full range, and it shall be verified that the actuators travel from zero stroke to full stroke within the signal range. It shall be verified that all sequenced and parallel-operated actuators move from zero stroke to full stroke in the proper direction, and move the connected device in the proper direction from one extreme position to the other.

d. Step 4 - Control System Commissioning:

(1) With the fans ready to start, the system shall be placed in the ventilation delay mode and in the occupied mode, and it shall

be verified that supply fan [_____] and return fan [_____] start. It shall be verified that the outside air and relief air dampers are closed, and the return air damper is open, by artificially changing the mixed air temperature through operator entered values. It shall be verified that the heating and cooling coil valves are under control, by artificially changing the hot and cold deck temperatures through operator entered values. The system shall be placed out of the ventilation delay mode through an operator entered value and it shall be verified that the outside air, return air, and relief air dampers come under control, by artificially changing the mixed air temperature.

(2) The control system shall be placed in the minimum outside air mode. It shall be verified that the outside air damper opens to minimum position.

(3) The economizer mode shall be simulated by a change in the outside air temperature and the return air temperature through operator entered values and it shall be verified that the system goes into the economizer mode. The mixed air temperature shall be artificially changed through operator entered values to slightly open the outside air damper and the second point of the two-point calibration accuracy check of sensing element-to-DDC system readout for outside air, return air, and mixed air temperatures shall be performed. The temperature setpoint shall be set as shown.

(4) The two-point calibration sensing element-to-DDC system readout accuracy check for the outside air temperature shall be performed. Any necessary software adjustments shall be made to setpoints or parameters to achieve the outside air temperature schedule as shown.

(5) The two-point calibration accuracy check of sensing element-to-DDC system readout for outside air and hot-deck temperatures shall be performed. The hot deck temperature setpoint shall be set for [_____] degrees F at 20-ma input and [_____] degrees F at 4-ma input. The outside air temperature shall be artificially changed through operator entered values. Three values shall be entered simulating outside air temperature changes. The values shall be selected at midrange, lower 1/3 range, and upper 1/3 range of the temperature schedule. It shall be verified that the hot-deck temperature setpoint tracks the schedule. The hot-deck temperature setpoint shall be set for the existing outside air temperature as shown. A change shall be simulated in the coil discharge air temperature through an operator entered value and it shall be verified that the control valve is modulated.

(6) The two-point calibration accuracy check of sensing element-to-DDC system readout for the hot-deck temperature shall be performed. The hot-deck temperature setpoint shall be set as shown. A change shall be simulated in the coil discharge air temperature through an operator entered value and it shall be verified that the control valve is modulated.

(7) The two-point calibration accuracy check of sensing element-to-DDC system readout for the cold-deck temperature shall

be performed. The cold-deck temperature setpoint shall be set as shown. A change shall be simulated in the coil discharge air temperature through an operator entered value and it shall be verified that the control valve is modulated.

(8) The control system shall be placed in the unoccupied mode, and it shall be verified that the HVAC system shuts down, and the control system assumes the specified shutdown conditions. The space temperature shall be artificially changed to below the night setback setpoint and it shall be verified that the HVAC system starts; the space temperature shall be artificially changed to above the night setback setpoint, and it shall be verified that the HVAC system stops. The night setback temperature setpoint shall be set as shown.

(9) With the HVAC system running, a filter differential pressure switch input signal shall be simulated at the device. It shall be verified that the filter alarm is initiated. The differential pressure switch shall be set at the setpoint.

(10) With the HVAC system running, a freezestat trip input signal shall be simulated at the device. HVAC system shutdown shall be verified. It shall be verified that a low temperature alarm is initiated. The freezestat shall be set at the setpoint. The HVAC system shall be restarted by manual restart and it shall be verified that the alarm returns to normal.

(11) With the HVAC system running, a smoke detector trip input signal shall be simulated at each detector, and control device actions and interlock functions as described in the Sequence of Operation shall be verified. Simulation shall be performed without false-alarming any Life Safety systems. It shall be verified that the HVAC system shuts down and that the smoke detector alarm is initiated. The detectors shall be reset. HVAC system shall be restarted by manual reset, and it shall be verified that the alarm signal is changed to a return-to-normal signal.

(12) The temperature setpoint of each zone thermostat shall be raised and it shall be verified that the zone damper closes to the cold-deck and opens to the hot-deck. Each zone thermostat shall be calibrated and set at its setpoint as shown.

3.4.15   Dual-Duct Multizone Control System with Return Fan

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NOTE: For subparagraph d, step 4 below, in a dual-duct multizone system, given that there is no deadband between heating and cooling, reliable operation of the economizer cycle may be difficult to achieve. An economizer cycle should only be used in this system if the unit is either served by a dual-temp hydronic system, or HW and CHW availability is scheduled (i.e.- only HW is available during the heating season and vice versa). If HW and CHW are both available year-round, then an economizer cycle should not be used. The following commissioning procedures should

be edited accordingly. (See TI 810-11 for further details on this subject.)

When an economizer cycle is not to be used, delete subparagraph d, step 4, subparagraph (3).

In subparagraph d, step 4, subparagraph (4), outside air reset of the hot-deck discharge temperature setpoint should not be used in conjunction with outside air reset of the heating water supply temperature. If outside air reset of the hot-deck discharge temperature is not being performed, delete this paragraph and the paragraph that follows.

If outside air reset of the hot-deck discharge temperature is being performed, delete subparagraph d, step 4, subparagraph (6).
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Steps for installation shall be as follows:

a. Step 1 - System Inspection: The HVAC system shall be observed in its shutdown condition. The system shall be checked to see that power and main air are available where required; that the outside air damper, relief air damper, and cooling coil valve are closed; and that the return air damper is open.

b. Step 2 - Calibration Accuracy Check with HVAC System Shutdown: Readings shall be taken with a digital thermometer at each temperature-sensing element location. Each temperature shall be read at the DDC controller, and the thermometer and DDC system readings logged. The calibration accuracy of the sensing element-to-DDC system readout for outside air, return air, mixed air, cold-deck, and hot-deck temperatures shall be checked.

c. Step 3 - Actuator Range Adjustments: A signal shall be applied to the actuator through an operator entered value to the DDC system. The proper operation of the actuators and positioners for all dampers and valves shall be verified. The signal shall be varied from live zero to full range, and it shall be verified that the actuators travel from zero stroke to full stroke within the signal range. It shall be verified that all sequenced and parallel-operated actuators move from zero stroke to full stroke in the proper direction, and move the connected device in the proper direction from one extreme position to the other.

d. Step 4 - Control System Commissioning:

(1) With the fans ready to start, the control system shall be placed in the ventilation delay mode and in the occupied mode, and it shall be verified that supply fan [_____] and return fan [_____] start. It shall be verified that the outside air and relief air dampers are closed, and the return air damper is open, by artificially changing the mixed air temperature through operator entered values. It shall be verified that the heating and cooling coil valves are under control, by artificially changing the hot and cold deck temperatures through operator entered values. The system shall be placed out of the ventilation delay mode through an operator entered value and it shall be

verified that the outside air, return air, and relief air dampers come under control, by artificially changing the mixed air temperature.

(2) The control system shall be placed in the minimum outside air mode. It shall be verified that the outside air damper opens to minimum position.

(3) The economizer mode shall be simulated by a change in the outside air temperature and the return air temperature through operator entered values and it shall be verified that the system goes into the economizer mode. The mixed air temperature shall be artificially changed through operator entered values to slightly open the outside air damper and the second point of the two-point calibration accuracy check of sensing element-to-DDC system readout for outside air, return air, and mixed air temperatures shall be performed. The temperature setpoint shall be set as shown.

(4) The two-point calibration sensing element-to-DDC system readout accuracy check for the outside air temperature shall be performed. Any necessary software adjustments shall be made to setpoints or parameters to achieve the outside air temperature schedule as shown.

(5) The two-point calibration accuracy check of sensing element-to-DDC system readout for outside air and hot-deck temperatures shall be performed. The hot-deck temperature setpoint shall be set for [_____] degrees F at 20-ma input and [_____] degrees F at 4-ma input. The outside air temperature shall be artificially changed through operator entered values. Three values shall be entered simulating outside air temperature changes. The values shall be selected at midrange, lower 1/3 range, and upper 1/3 range of the temperature schedule. It shall be verified that the hot-deck temperature setpoint tracks the schedule. The hot-deck temperature setpoint shall be set for the existing outside air temperature as shown. A change shall be simulated in the coil discharge air temperature through an operator entered value and it shall be verified that the control valve is modulated.

(6) The two-point calibration accuracy check of sensing element-to-DDC system readout for the hot-deck temperature shall be performed. The hot-deck temperature setpoint shall be set as shown. A change shall be simulated in the coil discharge air temperature through an operator entered value and it shall be verified that the control valve is modulated.

(7) The two-point calibration accuracy check of sensing element-to-DDC system readout for the cold-deck temperature shall be performed. The cold-deck temperature setpoint shall be set as shown. A change shall be simulated in the coil discharge air temperature through an operator entered value and it shall be verified that the control valve is modulated.

(8) The control system shall be placed in the unoccupied mode, and it shall be verified that the HVAC system shuts down, and the control system assumes the specified shutdown conditions. The

space temperature shall be artificially changed to below the night setback setpoint and it shall be verified that the HVAC system starts; the space temperature shall be artificially changed to above the night setback setpoint, and it shall be verified that the HVAC system stops. The night setback temperature setpoint shall be set as shown.

(9) With the HVAC system running, a filter differential pressure switch input signal shall be simulated at the device. It shall be verified that the filter alarm is initiated. The differential pressure switch shall be set at the setpoint.

(10) With the HVAC system running, a freezestat trip input signal shall be simulated at the device. HVAC system shutdown shall be verified. It shall be verified that a low temperature alarm is initiated. The freezestat shall be set at the setpoint. The HVAC system shall be restarted by manual restart and it shall be verified that the alarm returns to normal.

(11) With the HVAC system running, a smoke detector trip input signal shall be simulated at each detector, and control device actions and interlock functions as described in the Sequence of Operation shall be verified. Simulation shall be performed without false-alarming any Life Safety systems. It shall be verified that the HVAC system shuts down and that the smoke detector alarm is initiated. The detectors shall be reset. HVAC system shall be restarted by manual reset, and it shall be verified that the alarm signal is changed to a return-to-normal signal.

(12) The setpoint of each zone thermostat shall be raised and it shall be verified that the dual-duct terminal box damper closes to the cold duct and opens to the hot duct. Each zone thermostat shall be calibrated and set at its setpoint as shown.

3.4.16 Bypass Multizone with Return Fan

Steps for installation shall be as follows:

a. Step 1 - System Inspection: The HVAC system shall be observed in its shutdown condition. The system shall be checked to see that power and main air are available where required, the outside air damper, relief air damper, and cooling coil valve are closed, and the return air damper is open.

b. Step 2 - Calibration Accuracy Check with HVAC System Shutdown: Readings shall be taken with a digital thermometer at each temperature sensing element location. Each DDC controller display shall be read, and the thermometer and DDC system display readings logged. The calibration accuracy of the sensing element-to-DDC system readout for outside air, return air, mixed air, cold-deck temperatures shall be checked.

c. Step 3 - Actuator Range Adjustments: A signal shall be applied to the actuator through an operator entered value to the DDC system. The proper operation of the actuators and positioners for all dampers and valves shall be visually verified. The signal shall be varied from live zero to full range, and it shall be verified that the actuators travel from zero stroke to full stroke within the signal range. It shall be verified that all sequenced and parallel-operated actuators move from zero stroke to full stroke in the proper direction, and move the connected device in the proper direction from one extreme position to the other.

d. Step 4 - Control System Commissioning:

(1) With the fans ready to start, the control system shall be placed in the ventilation delay mode and in the occupied mode, and it shall be verified that supply fan [_____] and return fan [_____] start. It shall be verified that the outside air and relief air dampers are closed, the return air damper is open, and the heating and cooling coil valves are under control, by simulating a change in the temperature of the cooling coil discharge air and the space temperature through operator entered values. The control system shall be placed out of the ventilation delay mode, and it shall be verified that the outside air, return air, and relief air dampers come under control, by simulating a change in the mixed air temperature through operator entered values.

(2) The control system shall be placed in the minimum outside air mode. It shall be verified that the outside air damper opens to minimum position.

(3) The economizer mode shall be simulated by a change in the outside air temperature and the return air temperature through operator entered values and it shall be verified that the system goes into the economizer mode. The mixed air temperature shall be artificially changed through operator entered values to slightly open the outside air damper and the second point of the two-point calibration accuracy check of sensing element-to-DDC system readout for outside air, return air, and mixed air temperatures shall be performed. The temperature setpoint shall be set as shown.

(4) The two-point calibration accuracy check of sensing element-to-DDC system readout for the cold-deck temperature shall be performed. The cold-deck temperature setpoint shall be set as shown. A change shall be simulated in the coil discharge air temperature through an operator entered value and it shall be verified that the control valve is modulated.

(5) The control system shall be placed in the unoccupied mode and it shall be verified that the HVAC system shuts down, and the control system assumes the specified shutdown conditions. The space temperature shall be artificially changed to below the night setback temperature setpoint, and it shall be verified that the HVAC system starts; the space temperature shall be artificially changed to above the night setback setpoint, and it shall be verified that the HVAC system stops. The night setback temperature setpoint shall be set at the setpoint as shown.

(6) With the HVAC system running, a filter differential pressure switch input signal shall be simulated at the device. It shall be verified that the filter alarm is initiated. The differential pressure switch shall be set at the setpoint.

(7) With the HVAC system running, a freezestat trip input signal

shall be simulated at the device. HVAC system shutdown shall be verified. It shall be verified that a low-temperature alarm is initiated. The freezestat shall be set at the setpoint. The HVAC system shall be restarted by manual restart and it shall be verified that the alarm returns to normal.

(8) With the HVAC system running, a smoke detector trip input signal shall be simulated at each detector, and control device actions and interlock functions as described in the Sequence of Operation shall be verified. Simulation shall be performed without false-alarming any Life Safety systems. It shall be verified that the HVAC system shuts down and that the smoke detector alarm is initiated. The detectors shall be reset. The HVAC system shall be restarted by manual reset, and it shall be verified that the alarm signal is changed to a return-to-normal signal.

(9) The setpoint of each room thermostat shall be changed and correct operation of the zone damper and the heating coil valve shall be verified for each zone. Each room thermostat shall be calibrated and set at its setpoint.

3.4.17 Variable Air Volume Control System - Without Return Fan

Steps for installation shall be as follows:

a. Step 1 - System Inspection: The HVAC system shall be observed in its shutdown condition. The system shall be checked to see that power and main air are available where required, the outside air and relief air dampers are closed, the return air damper is open, and the supply fan inlet vanes and cooling coil valve are closed.

b. Step 2 - Calibration Accuracy Check with HVAC System in Shutdown: Readings shall be taken with a digital thermometer at each temperature sensing element location. Each temperature shall be read at the DDC controller, and the thermometer and DDC system display readings logged. The calibration accuracy of the sensing element-to-DDC system readout for outside air, return air, mixed air, and the cooling coil discharge temperatures shall be checked. The minimum outside air flow shall be read, using a digital indicating velometer, and the velometer and DDC system display readings logged. The flow should read zero.

c. Step 3 - Actuator Range Adjustments: A signal shall be applied to the actuators through an operator entered value to the DDC system. The proper operation of the actuators and positioners for all dampers and valves shall be visually verified. The signal shall be varied from live zero to full range, and it shall be verified that the actuators travel from zero stroke to full stroke within the signal range. It shall be verified that all sequenced and parallel operated actuators move from zero stroke to full stroke in the proper direction, and move the connected device in the proper direction from one extreme position to the other.

d. Step 4 - Control System Commissioning:

(1) With the fan ready to start, the control system shall be placed in the ventilation delay mode and in the occupied mode through operator entered values. It shall be verified that supply fan [_____] starts. It shall be verified that the outside air

dampers and relief damper are closed, the return air damper is open, and the cooling coil valve and inlet vanes are under control, by simulating a change in the fan discharge temperature. The system shall be placed out of the ventilation delay mode, and it shall be verified that the economizer outside air and relief air dampers remain closed, the return air damper remains open, and the minimum outside air damper comes under control.

(2) The two-point calibration accuracy check of sensing element-to-DDC system readout for the minimum outside air flow measurement station shall be performed. Force all VAV box dampers to the full open position, turn all exhaust fans off, manually adjust the supply duct static pressure to achieve the design duct static pressure, and manually adjust the minimum outside air flow to achieve a flow which is approximately 25% less than the desired air flow. Under these conditions, the minimum outside air flow control loop shall be tuned. Confirm stable operation of the minimum outside air flow control loop in response to a process disturbance.

(3) With supply fan [_____] running, a high static pressure input signal shall be simulated at the device, by pressure input to the differential pressure switch sensing device. HVAC system shutdown shall be verified; it shall be verified that the high static pressure alarm is initiated. The differential pressure switch shall be set at the setpoint. The HVAC system shall be restarted by manual reset, and it shall be verified that the high static pressure alarm returns to normal.

(4) The two-point calibration accuracy check for sensing element-to-DDC system readout for the static pressure in the supply duct shall be performed.

(5) The economizer mode shall be simulated by a change in the outside air temperature and the return air temperature through operator entered values and it shall be verified that the system goes into the economizer mode. The mixed air temperature shall be artificially changed through operator entered values to slightly open the economizer outside air damper and the second point of the two-point calibration accuracy check of sensing element-to-DDC system readout for outside air, return air, and mixed air temperatures shall be performed. The temperature setpoint shall be set as shown.

(6) The two-point calibration accuracy check of sensing element-to-DDC system readout for the fan discharge temperature shall be performed. The setpoint for the fan discharge temperature shall be set as shown. A change shall be simulated in the discharge air temperature through an operator entered value and it shall be verified that the control valve is modulated.

(7) The control system shall be placed in the unoccupied mode and it shall be verified that the HVAC system shuts down and the control system assumes the specified shutdown conditions. The space temperature shall be artificially changed to below the night setback temperature setpoint, and it shall be verified that the HVAC system starts; the space temperature shall be artificially changed to above the night setback setpoint, and it shall be

verified that the HVAC system stops. The night setback temperature setpoint shall be set at the setpoint shown.

(8) With the HVAC system running, a filter differential pressure switch input signal shall be simulated at the device. It shall be verified that the filter alarm is initiated. The differential pressure switch shall be set at the setpoint. This shall be performed for each filter.

(9) With the HVAC system running, a freezestat trip input signal shall be simulated at the device. HVAC system shutdown shall be verified. It shall be verified that a low temperature alarm is initiated. The freezestat shall be set at the setpoint. The HVAC system shall be restarted by manual restart and it shall be verified that the alarm returns to normal.

(10) With the HVAC system running, a smoke detector trip input signal shall be simulated at each detector, and control device actions and interlock functions as described in the Sequence of Operation shall be verified. Simulation shall be performed without false-alarming any Life Safety systems. It shall be verified that the HVAC system shuts down and the smoke detector alarm is initiated. The detectors shall be reset. The HVAC system shall be restarted by manual reset, and it shall be verified that the alarm returns to normal.

(11) Velocity setpoints shall be set for minimum and maximum flow and temperature setpoints for the heating/cooling dead band, for each VAV terminal unit. The actions of the controller, the operation of the damper, and the operation of heating shall be verified. It shall be verified that space temperature is maintained.

3.4.18 Variable Air Volume Control System - With Return Fan

Steps for installation shall be as follows:

a. Step 1 - System Inspection: The HVAC system shall be observed in its shutdown condition. It shall be verified that power and main air are available where required, and that the outside air and relief air dampers are closed, the return air damper is open, and that the supply fan and return/relief fan inlet vanes and cooling coil valve are closed.

b. Step 2 - Calibration Accuracy Check with HVAC System Shutdown: Readings shall be taken with a digital thermometer at each temperature sensing element location. Each temperature shall be read at the DDC controller, and the thermometer and DDC system display readings logged. The calibration accuracy of the sensing element-to-DDC system readout for outside air, return air, mixed air, and cooling coil discharge temperatures shall be checked. The minimum outside air flow, supply air flow, and return air flow shall be read, using a digital indicating velometer, and the velometer and DDC system display readings logged. The flows should read zero.

c. Step 3 - Actuator Range Adjustments: A signal shall be applied to the actuators through an operator entered value at the DDC system. The proper operation of the actuators and positioners for all dampers and valves shall be visually verified. The signal shall be varied from live zero to full range, and actuator travel shall be verified from zero stroke to full stroke within the signal range. It shall be verified that all sequenced and parallel operated actuators move from zero stroke to full stroke in the proper direction, and move the connected device in the proper direction from one extreme position to the other.

d. Step 4 - Control System Commissioning:

(1) With the fans ready to start, the control system shall be placed in the ventilation delay mode and in the occupied mode, and it shall be verified that supply fan [_____] and return fan [_____] start. It shall be verified that the outside air dampers and relief air damper are closed, the return air damper is open, and the cooling coil valve and inlet vanes are under control, by simulating a change in the fan discharge temperature. The system shall be placed out of the ventilation delay mode, and it shall be verified that the economizer outside air and relief air dampers remain closed, the return air damper remains open, and the minimum outside air damper comes under control.

(2) The two-point calibration accuracy check of sensing element-to-DDC system readout for the minimum outside air flow measurement station shall be performed. Force all VAV box dampers to the full open position, turn all exhaust fans off, manually adjust the supply duct static pressure to achieve the design duct static pressure, manually adjust the output to the return fan to establish the design differential flow difference between the supply and return duct flows, and manually adjust the minimum outside air flow to achieve a flow which is approximately 25% less than the desired air flow. Under these conditions, the minimum outside air flow control loop shall be tuned. Confirm stable operation of the minimum outside air flow control loop in response to a process disturbance.

(3) The starter switch of return fan [_____] shall be turned to the "OFF" position, and the inlet vane damper shall be opened. With supply fan [_____] running, a high static pressure input signal shall be simulated at the device by a pressure input to the sensing device. HVAC system shutdown shall be observed, and it shall be verified that the high static alarm is initiated. The HVAC system shall be restarted by manual reset, and it shall be verified that the high static alarm returns to normal.

(4) The two-point accuracy check of sensing element-to-DDC system readout for the static pressure in the supply duct shall be performed.

(5) Each VAV terminal unit controller's minimum flow and maximum flow setpoints shall be set at the same setting. This will prevent the VAV box damper from modulating under space temperature control and will achieve a constant supply duct system pressure drop. The return fan inlet vane shall be placed under control, and the starter switch shall be turned to the "AUTO" position so that the fan starts. The two-point calibration accuracy check of sensing element-to-DDC system readout for the air flow measurement stations shall be performed. The supply fan inlet vane shall be operated manually to change the supply fan flow, and the control system shall be set to control at [_____] cfm at 4-ma input and

[_____] cfm at 20-ma input. The supply fan flow shall be changed to verify that the return flow setpoint tracks the supply fan flow with the proper flow differential.

(6) The economizer mode shall be simulated by a change in the outside air temperature and the return air temperature through operator entered values and it shall be verified that the system goes into the economizer mode. The mixed air temperature shall be artificially changed through operator entered values to slightly open the economizer outside air damper and the second point of the two-point calibration accuracy check of sensing element-to-DDC system readout for outside air, return air, and mixed air temperatures shall be performed. The temperature setpoint shall be set as shown.

(7) The two-point calibration accuracy check of sensing element-to-DDC system readout for the fan discharge temperature shall be performed. The setpoint for the fan discharge temperature shall be set as shown. A change shall be simulated in the discharge air temperature through an operator entered value and it shall be verified that the control valve is modulated.

(8) The control system shall be placed in the unoccupied mode and it shall be verified that the HVAC system shuts down and the control system assumes the specified shutdown conditions. The space temperature shall be artificially changed to below the night setback temperature setpoint, and it shall be verified that the HVAC system starts; the space temperature shall be artificially changed to above the night setback temperature setpoint and it shall be verified that the HVAC system stops. The night setback temperature setpoint shall be set at the setpoint.

(9) With the HVAC system running, a filter differential pressure switch input signal shall be simulated at the device. It shall be verified that the filter alarm is initiated. The differential pressure switch shall be set at the setpoint as shown. This shall be performed for each filter.

(10) With the HVAC system running, a freezestat trip input signal shall be simulated at the device. HVAC system shutdown shall be verified. It shall be verified that a low temperature alarm is initiated. The freezestat shall be set at the setpoint as shown. The HVAC system shall be restarted by manual restart and it shall be verified that the alarm returns to normal.

(11) With the HVAC system running, a smoke detector trip input signal shall be simulated at each device. Control device actions and interlock functions as described in the Sequence of Operation shall be verified. Simulation shall be performed without false-alarming any Life Safety systems. It shall be verified that the HVAC system shuts down and the smoke detector alarm is initiated. The detectors shall be reset. The HVAC system shall be restarted by manual reset, and the alarm return-to-normal shall be verified.

(12) For each VAV terminal unit, velocity setpoints shall be set for minimum and maximum flow, and temperature setpoints for the heating/cooling dead band. The actions of the controller, the

operation of the damper, and the operation of heating shall be verified. It shall be verified that space temperature is maintained.

3.4.19 Single Zone with Hydronic Heating and Cooling Coils; No Return Fan

Steps for installation shall be as follows:

a. Step 1 - System Inspection: The HVAC system shall be verified in its shutdown condition. The system shall be checked to see that power and main air are available where required, that the outside air damper, relief air damper, and cooling coil valve are closed, and that the return air damper is open.

b. Step 2 - Calibration Accuracy Check with HVAC System Shutdown: Readings shall be taken with a digital thermometer at each temperature sensing element location. Each temperature shall be read at the DDC controller, and the thermometer and DDC system display readings logged. The calibration accuracy of the sensing element-to-DDC system readout for outside air, return air, and space temperatures shall be checked.

c. Step 3 - Actuator Range Adjustments: A signal shall be applied to the actuator through an operator entered value to the DDC system. The proper operation of the actuators and positioners for all dampers and valves shall be visually verified. The signal shall be varied from live zero to full range, and the actuator travel from zero stroke to full stroke within the signal range shall be verified. It shall be verified that all sequenced and parallel-operated actuators move from zero stroke to full stroke in the proper direction, and move the connected device in the proper direction from one extreme position to the other.

d. Step 4 - Control System Commissioning:

(1) With the fan ready to start, the control system shall be placed in the ventilation delay mode and in the occupied mode, and it shall be verified that supply fan [_____] starts. It shall be verified that the outside air and relief air dampers are closed, the return air damper is open, and the heating coil and cooling coil valves are under control, by simulating a change in the space temperature through an operator entered value. The control system shall be placed out of the ventilation delay mode, and it shall be verified that the outside air, return air, and relief air dampers come under control by simulating a change in the space temperature.

(2) The control system shall be placed in the minimum outside air mode. It shall be verified that the outside air damper opens to minimum position.

(3) The economizer mode shall be simulated by a change in the outside air temperature and the return air temperature through operator entered values and it shall be verified that the system goes into the economizer mode. The space temperature shall be artificially changed through operator entered values to slightly open the outside air damper and the second point of the two-point calibration accuracy check of sensing element-to-DDC system readout for outside air, return air, and space temperatures shall be performed. The space temperature setpoint shall be set as shown.

(4) An unoccupied mode signal shall be applied, and it shall be verified that the HVAC system shuts down, and the control system assumes the specified shutdown conditions. The space temperature shall be artificially changed to below the night setback temperature setpoint, and it shall be verified that the HVAC system starts; the space temperature shall be set to above the night setback setpoint, and it shall be verified that the HVAC system stops. The night setback temperature setpoint shall be set at the setpoint as shown.

(5) With the HVAC system running, a filter differential pressure switch input signal shall be simulated at the device. It shall be verified that the filter alarm is initiated. The differential pressure switch shall be set at the setpoint.

(6) With the HVAC system running, a freezestat trip input signal shall be simulated at the device. HVAC system shutdown shall be verified. It shall be verified that a low temperature alarm is initiated. The freezestat shall be set at the setpoint. The HVAC system shall be restarted by manual restart and it shall be verified that the alarm returns to normal.

(7) With the HVAC system running, a smoke detector trip input signal at each detector shall be simulated, and control device actions and interlock functions as described in the Sequence of Operation shall be verified. Simulation shall be performed without false-alarming any Life Safety systems. It shall be verified that the HVAC system shuts down and that the smoke detector alarm is initiated. The detectors shall be reset. The HVAC system shall be restarted by manual reset, and it shall be verified that the alarm returns to normal.

3.4.20 Single Zone with Dual Temperature Coil; No Return Fan

Steps for installation shall be as follows:

a. Step 1 - System Inspection: The HVAC system shall be verified in its shutdown condition. The system shall be checked to see that power and main air are available where required, the outside air damper, relief air damper, and cooling coil valve are closed, and that the return air damper is open.

b. Step 2 - Calibration Accuracy Check with HVAC System Shutdown: Readings shall be taken with a digital thermometer at each temperature sensing element location. Each temperature shall be read at the DDC controller, and the thermometer and DDC system display readings logged. The calibration accuracy of the sensing element-to-DDC system readout shall be checked for outside air, return air, and space temperatures.

c. Step 3 - Actuator Range Adjustments: A signal shall be applied to the actuator through an operator entered value to the DDC system. The proper operation of the actuators and positioners for all dampers and valves shall be visually verified. The signal shall be varied from live zero to full range, and it shall be verified that the actuators travel from zero stroke to full stroke within the signal range. It shall be verified that all sequenced and parallel operated actuators move from zero stroke to full stroke in the proper direction and move the connected device in the proper direction from one extreme position to the other.

d. Step 4 - Control System Commissioning:

(1) With the fan ready to start, the control system shall be placed in the ventilation delay mode and in the occupied mode, and it shall be verified that supply fan [_____] starts. It shall be verified that the outside air and relief air dampers are closed, the return air damper is open, and the dual-temperature coil control valve is under control, by simulating a change in the space temperature. The control system shall be placed out of the ventilation delay mode, and it shall be verified that the outside air, return air, and relief air dampers come under control by simulating a change in the controller output.

(2) The control system shall be placed in the minimum outside air mode. It shall be verified that the outside air damper opens to minimum position.

(3) The economizer mode shall be simulated by a change in the outside air temperature and the return air temperature through operator entered values and it shall be verified that the system goes into the economizer mode. The space temperature shall be artificially changed through operator entered values to slightly open the outside air damper and the second point of the two-point calibration accuracy check of sensing element-to-DDC system readout for outside air, return air, and space temperatures shall be performed. The space temperature setpoint shall be set as shown.

(4) Dual-temperature hydronic changeover operation of aquastat shall be simulated. Control system selection of opposite season space temperature control shall be verified by artificially changing the dual-temperature hydronic temperature.

(5) The control system shall be placed in the unoccupied mode, and it shall be verified that the HVAC system shuts down, and the control system assumes the specified shutdown conditions. The space temperature shall be artificially changed to below the night setback temperature setpoint, and it shall be verified that the HVAC system starts; the space temperature shall be artificially changed to above the night setback temperature setpoint and it shall be verified that the HVAC system stops. The night setback temperature setpoint shall be set at the setting as shown.

(6) With the HVAC system running, a filter differential pressure switch input signal shall be simulated at the device. It shall be verified that the filter alarm is initiated. The differential pressure switch shall be set at the setpoint.

(7) With the HVAC system running, a freezestat trip input signal shall be simulated at the device. HVAC system shutdown shall be verified. It shall be verified that a low temperature alarm is initiated. The freezestat shall be set at the setpoint. The HVAC system shall be restarted by manual restart and it shall be verified that the alarm returns to normal.

(8) With the HVAC system running, a smoke detector trip input signal shall be simulated at each detector, and control device actions and interlock functions as described in the Sequence of

Operation shall be verified. Simulation shall be performed without false-alarming any Life Safety systems. It shall be verified that the HVAC system shuts down and that the smoke detector alarm is initiated. The detectors shall be reset. The HVAC system shall be restarted by manual reset, and it shall be verified that the alarm returns to normal.

3.4.21 Single Zone with Humidification; No Return Fan

Steps for installation shall be as follows:

a. Step 1 - System Inspection: The HVAC system shall be verified in its shutdown condition. The system shall be checked to see that power and main air are available where required, and that the outside air damper, humidifier valve and cooling coil valve are closed.

b. Step 2 - Calibration Accuracy Check with HVAC System Shutdown: Readings shall be taken with a digital thermometer at each temperature sensing elements location. Each temperature shall be read at the DDC controller, and the thermometer and DDC system display readings logged. The calibration accuracy of the sensing element-to-DDC system readout for outside air, return air, mixed air, and cooling coil discharge temperatures shall be checked. A motor-driven psychrometer shall be used to check the wet-bulb and dry-bulb temperatures of the humidifier discharge air and of the air in the space, and the psychrometer, and DDC system display readings shall be read and logged.

c. Step 3 - Actuator Range Adjustments: A signal shall be applied to the actuator, through an operator entered value to the DDC system. The proper operation of the actuators and positioners for all dampers and valves shall be visually verified. The signal shall be varied from live zero to full range, and the actuators travel shall be verified from zero stroke to full stroke within the signal range. It shall be verified that all sequenced and parallel operated actuators move from zero stroke to full stroke in the proper direction, and move the connected device in the proper direction from one extreme position to the other.

d. Step 4 - Control System Commissioning:

(1) With the fan ready to start, the control system shall be placed in the ventilation delay mode and in the occupied mode, and it shall be verified that supply fan [_____] starts. It shall be verified that the outside air damper is closed, and the heating coil, cooling coil, and humidifier valves are under control, by simulating a change in the space humidity and the space temperature. The system shall be placed out of the ventilation delay mode, and it shall be verified that the outside air damper opens.

(2) The two-point calibration accuracy check of sensing element-to-DDC system readout for the preheat coil discharge air temperature shall be performed. The setpoint for the coil discharge air temperature shall be set as shown. A change shall be simulated in the coil discharge air temperature through an operator entered value and it shall be verified that the preheat coil control valve is modulated.

(3) The calibration accuracy check for sensing element-to-DDC

system readout for the space temperature shall be performed. The space temperature setpoint shall be set as shown. A change shall be simulated in the space temperature and it shall be verified that the heating coil valve and cooling coil valve are under control.

(4) The calibration accuracy check for sensing element-to-DDC system readout for the space relative humidity shall be performed. An identical calibration accuracy check for the duct relative humidity shall be performed. The space relative humidity and the duct relative humidity setpoints shall be set as shown. A change shall be simulated in the space relative humidity or in the duct relative humidity and it shall be verified that the humidifier valve and cooling coil valve are under control.

(5) The hydronic heating temperature controller "MANUAL/AUTO" station shall be indexed to the "MANUAL" position. The controller output shall be changed to open the converter valve slightly. The 2-point calibration accuracy check for sensing element-to-DDC system readout for the space temperature shall be performed. The temperature setpoint shall be set as shown.

(6) The control system shall be placed in the unoccupied mode and it shall be verified that the HVAC system shuts down, and the control system assumes the specified shutdown conditions. The space temperature shall be artificially changed to below the night setback temperature setpoint and it shall be verified that the HVAC system starts; the space temperature shall be artificially changed to above the night setback temperature setpoint, and it shall be verified that the HVAC system stops. The night setback temperature setpoint shall be set at the setpoint as shown.

(7) With the HVAC system running, a filter differential pressure switch input signal shall be simulated at the device. It shall be verified that the filter alarm is initiated. The differential pressure switch shall be set at the setpoint.

(8) With the HVAC system running, a freezestat trip input signal shall be simulated at the device. HVAC system shutdown shall be verified. It shall be verified that a low temperature alarm is initiated. The freezestat shall be set at the setpoint. The HVAC system shall be restarted by manual restart and it shall be verified that the alarm returns to normal.

(9) With the HVAC system running, a smoke detector trip input signal shall be simulated at each detector, and control device actions and interlock functions as described in the Sequence of Operation shall be verified. Simulation shall be performed without false-alarming any Life Safety systems. It shall be verified that the HVAC system shuts down and that the smoke detector alarm is initiated. The detectors shall be reset. The HVAC system shall be restarted by manual reset, and it shall be verified that the alarm returns to normal.

3.4.22 Single Zone with Hydronic Heating Direct Expansion Cooling

Steps for installation shall be as follows:

a. Step 1 - System Inspection: The HVAC system shall be verified in its shutdown condition. The system shall be checked to see that power and main air are available where required, the outside air damper and relief air damper are closed, all stages of cooling are off, and that the return air damper is open.

b. Step 2 - Calibration Accuracy Check with HVAC System Shutdown: Readings shall be taken with a digital thermometer at each temperature sensing element location. Each temperature shall be read at the DDC controller, and the thermometer and DDC system display readings logged. The calibration accuracy of the sensing element-to-DDC system readout for outside air, return air, and space temperatures shall be checked.

c. Step 3 - Actuator Range Adjustments: A signal shall be applied to the actuator, through an operator entered value to the DDC system. The proper operation of the actuators and positioners for all dampers and valves shall be visually verified. The signal shall be varied from live zero of 4 ma to 20 ma, and it shall be verified that the actuators travel from zero stroke to full stroke within the signal range. It shall be verified that all sequenced and parallel operated actuators move from zero stroke to full stroke in the proper direction and move the connected device in the proper direction from one extreme position to the other. Example: NC actuators are closed at 4 ma and are open at 20 ma. The signal levels that move the controlled device to its extreme positions shall be logged. The operating points of the sequence shall be set for each stage of cooling and the proper operation of each stage shall be verified.

d. Step 4 - Control System Commissioning:

(1) With the fan ready to start, the control system shall be placed in the ventilation delay mode and in the occupied mode, and it shall be verified that supply fan [_____] starts. It shall be verified that the outside air and relief air dampers are closed, the return air damper is open, and the heating coil and stages of cooling are under control, by simulating a change in the space temperature. The control system shall be placed out of the ventilation delay mode, and it shall be verified that the outside air, return air, and relief air dampers come under control by simulating a change in the mixed air temperature.

(2) The control system shall be placed in the minimum outside air mode. It shall be verified that the outside air damper opens to minimum position.

(3) The economizer mode shall be simulated by a change in the outside air temperature and the return air temperature through operator entered values and it shall be verified that the system goes into the economizer mode. The space temperature shall be artificially changed through operator entered values to slightly open the outside air damper and the second point of the two-point calibration accuracy check of sensing element-to-DDC system readout for outside air, return air, and space temperatures shall be performed. The space temperature setpoint shall be set as shown. A change in space temperature shall be simulated and it shall be verified that the heating coil valve and the stages of D/X cooling operate in sequence as shown.

(4) The control system shall be placed in the unoccupied mode,

and it shall be verified that the HVAC system shuts down, and the control system assumes the specified shutdown conditions. The space temperature shall be artificially changed to below the night setback temperature setpoint, and it shall be verified that the HVAC system starts; the space temperature shall be artificially changed to above the night setback temperature setpoint, and it shall be verified that the HVAC system stops. The night setback temperature setpoint shall be set at the setpoint as shown.

(5) With the HVAC system running, a filter differential pressure switch input signal shall be simulated at the device. It shall be verified that the filter alarm is initiated. The differential pressure switch shall be set at the setpoint as shown.

(6) With the HVAC system running, a freezestat trip input signal shall be simulated at the device. HVAC system shutdown shall be verified. It shall be verified that a low-temperature alarm is initiated. The freezestat shall be set at the setpoint. The HVAC system shall be restarted by manual restart and it shall be verified that the alarm returns to normal.

(7) With the HVAC system running, a smoke detector trip input signal shall be simulated at each detector, and control device actions and interlock functions as described in the Sequence of Operation shall be verified. Simulation shall be performed without false-alarming any Life Safety systems. It shall be verified that the HVAC system shuts down and that the smoke detector alarm is initiated. The detectors shall be reset. The HVAC system shall be restarted by manual reset, and it shall be verified that the alarm returns to normal.

3.5 BALANCING, COMMISSIONING, AND TESTING

3.5.1 Coordination with HVAC System Balancing

Commissioning of the control system, except for tuning of controllers, shall be performed prior to or simultaneous with HVAC system balancing. The contractor shall tune the HVAC control system after all air system and hydronic system balancing has been completed, minimum damper positions set and a report has been issued.

3.5.2 Control System Calibration, Adjustments, and Commissioning

Control system commissioning shall be performed for each HVAC system, using test plans and procedures previously approved by the Government. The Contractor shall provide all personnel, equipment, instrumentation, and supplies necessary to perform commissioning and testing of the HVAC control system. All instrumentation and controls shall be calibrated and the specified accuracy shall be verified using test equipment with calibration traceable to NIST standards. Wiring shall be tested for continuity and for ground, open, and short circuits. Tubing systems shall be tested for leaks. Mechanical control devices shall be adjusted to operate as specified. HVAC control panels shall be pretested off-site as a functioning assembly ready for field connections, calibration, adjustment, and commissioning of the operational HVAC control system. Control parameters and logic (virtual) points including control loop setpoints, gain constants, and integral constraints, shall be adjusted before the system is placed on line. Communications requirements shall be as indicated. Written notification of any planned commissioning or testing of the HVAC Control systems shall be given to the Government at least 14 calendar days in advance.

3.5.3 Performance Verification Test

The Contractor shall demonstrate compliance of the HVAC control system with the contract documents. Using test plans and procedures previously approved by the Government, the Contractor shall demonstrate all physical and functional requirements of the project. The performance verification test shall show, step-by-step, the actions and results demonstrating that the control systems perform in accordance with the sequences of operation. The performance verification test shall not be started until after receipt by the Contractor of written permission by the Government, based on Government approval of the Commissioning Report and completion of balancing. The tests shall not be conducted during scheduled seasonal off periods of base heating and cooling systems.

3.5.4 Endurance Test

The endurance test shall be used to demonstrate the specified overall system reliability requirement of the completed system. The endurance test shall not be started until the Government notifies the Contractor in writing that the performance verification test is satisfactorily completed. The Government may terminate the testing at any time when the system fails to perform as specified. Upon termination of testing by the Government or by the Contractor, the Contractor shall commence an assessment period as described for Phase II. Upon successful completion of the endurance test, the Contractor shall deliver test reports and other documentation as specified to the Government prior to acceptance of the system.

a. Phase I (Testing). The test shall be conducted 24 hours per day, 7 days per week, for 15 consecutive calendar days, including holidays, and the system shall operate as specified. The Contractor shall make no repairs during this phase of testing unless authorized by the Government in writing.

b. Phase II (Assessment). After the conclusion of Phase I, the Contractor shall identify failures, determine causes of failures, repair failures, and deliver a written report to the Government. The report shall explain in detail the nature of each failure, corrective action taken, results of tests performed, and shall recommend the point at which testing should be resumed. After delivering the written report, the Contractor shall convene a test review meeting at the jobsite to present the results and recommendations to the Government. As a part of this test review meeting, the Contractor shall demonstrate that all failures have been corrected by performing appropriate portions of the performance verification test. Based on the Contractor's report and test review meeting, the Government may require that the Phase I test be totally or partially rerun. After the conclusion of any retesting which the Government may require, the Phase II assessment shall be repeated as if Phase I had just been completed.

3.5.5 Posted and Panel Instructions

Posted and Panel Instructions, showing the final installed conditions, shall be provided for each system. The posted instructions shall consist of laminated half-size drawings and shall include the control system schematic, equipment schedule, sequence of operation, wiring diagram, communication network diagram, and valve and damper schedules. The posted instructions shall be permanently affixed, by mechanical means, to a wall near the control panel. Panel instructions shall consist of laminated letter-size sheets and shall include a Routine Maintenance Checklist and as-built configuration check sheets. Panel instructions and one copy of the Operation and Maintenance Manuals, previously described herein, shall be placed inside each control panel or permanently affixed, by mechanical means, to a wall near the panel.

3.6 TRAINING

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NOTE: Training requirements should be coordinated with the user. Extent of training should be based on the needs of the installation personnel.
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3.6.1 Training Course Requirements

A training course shall be conducted for [_____] operating staff members designated by the Contracting Officer in the maintenance and operation of the system, including specified hardware and software. The training period, for a total of [32] [_____] hours of normal working time, shall be conducted within 30 days after successful completion of the performance verification test. The training course shall be conducted at the project site. Audiovisual equipment and [_____] sets of all other training materials and supplies shall be provided. A training day is defined as 8 hours of classroom instruction, including two 15 minute breaks and excluding lunchtime, Monday through Friday, during the daytime shift in effect at the training facility.

3.6.2 Training Course Content

For guidance in planning the required instruction, the Contractor shall assume that attendees will have a high school education or equivalent, and are familiar with HVAC systems. The training course shall cover all of the material contained in the Operating and Maintenance Instructions, the layout and location of each HVAC control panel, the layout of one of each type of unitary equipment and the locations of each, the location of each control device external to the panels, the location of the compressed air station, preventive maintenance, troubleshooting, diagnostics, calibration, adjustment, commissioning, tuning, and repair procedures. Typical systems and similar systems may be treated as a group, with instruction on the physical layout of one such system. The results of the performance verification test and the calibration, adjustment and commissioning report shall be presented as benchmarks of HVAC control system performance by which to measure operation and maintenance effectiveness.

-- End of Section --